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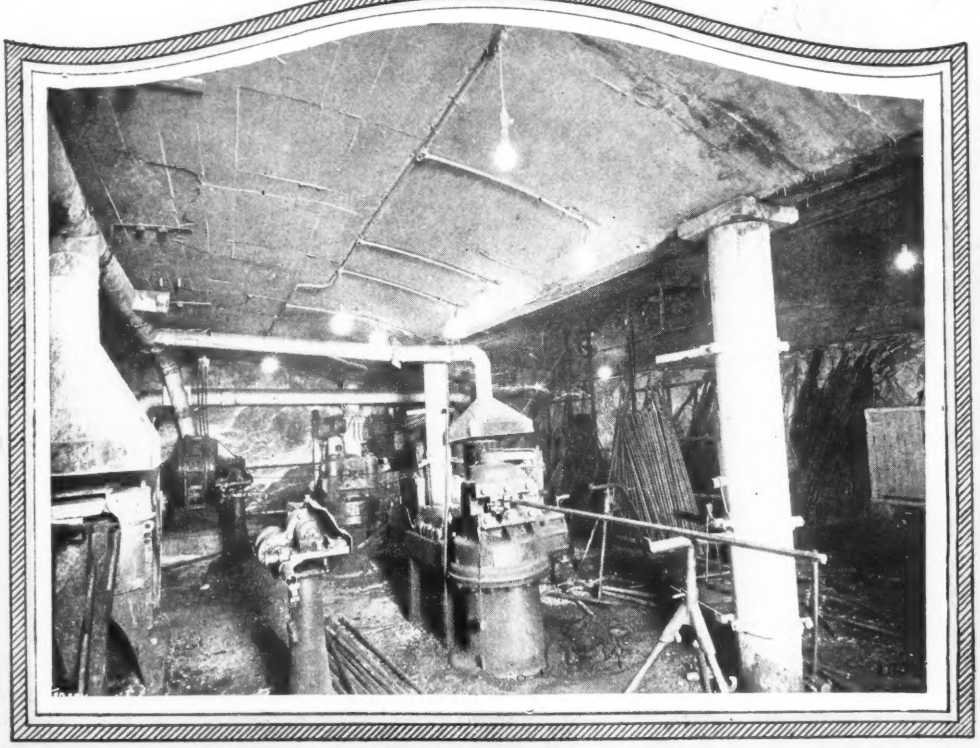

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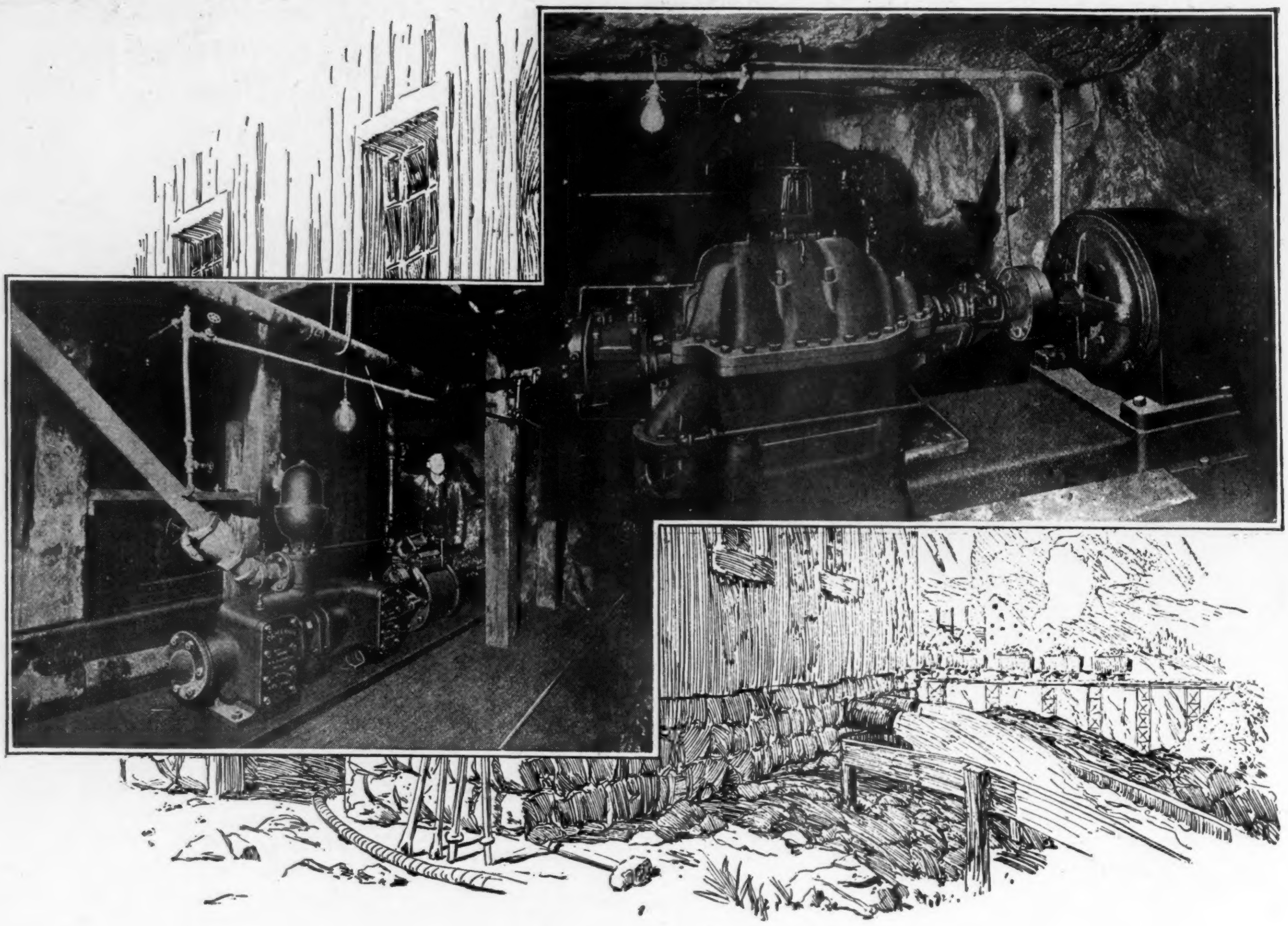

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VOL. XXVII, NO. 1

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What Modern Cold Storage Means to Us

The Ammonia Compressor Performs An Important Service in Refrigeration Which Assures Our Modern Cities of Abundant Food Supplies

By ROBERT G. SKERRETT

PROBABLY NO SINGLE department of inventive cunning has done more towards amplifying the world's food supplies year in and year out than the evolution of artificial refrigeration; and the benefits of this are nowhere more fully enjoyed than in America.

Strange as it may seem, the cold of Nature's ordering which so effectually halts the fruitfulness of the soil and arrests the developmental processes of vegetable life generally may, when simulated by man, be the very means of preserving perishable comestibles so that the plenty of summer will be available during the frigid months of winter. Not only that, but this same artificial cold may be utilized to offset the deteriorating action of seasonal heat.

Away back in 1845, Doctor John Gorrie, of Florida, conceived his modest cold-air refrigerating machine, by means of which ice could be produced in the hottest weather. Then and there he gave to us the cornerstone of an industrial structure which has since grown to magnificent proportions. Thanks to him, we have to-day instrumentalities which render it practicable to wipe out the boundaries of differing climes, to temper the stress of torrid temperatures, and to accomplish a remarkable interchange and a far-flung distribution of foodstuffs of all sorts.

It was not so long ago when the rural dweller kept his perishable edibles in a bucket hung down in the well or achieved the same end in the cool darkness of a cellar that boasted nothing in the shape of a heating plant. In those days, too, each urban population obtained most of its foodstuffs from the neighboring countryside; and the radius of this field of supply was of necessity decidedly limited. There was a summer dietary as well as a winter one, and in some essentials these were radically dissimilar. Further, some sections of the country contrasted sharply with others in the matter of the variety of the fare at their disposal, and this state of affairs was reflected in the health and the physique of the people in a more or less marked degree.

FEW OF us realize how intimately cold storage is linked with our physical well-being or how extensively this system of preserving foodstuffs is employed for the common good. Simply stated, it involves the principles of the domestic icebox applied more scientifically and upon a magnificent scale.

In the course of a twelvemonth, our cold storage warehouses hold for seasonal or gradual distribution foodstuffs totaling in value more than $200,000,000.

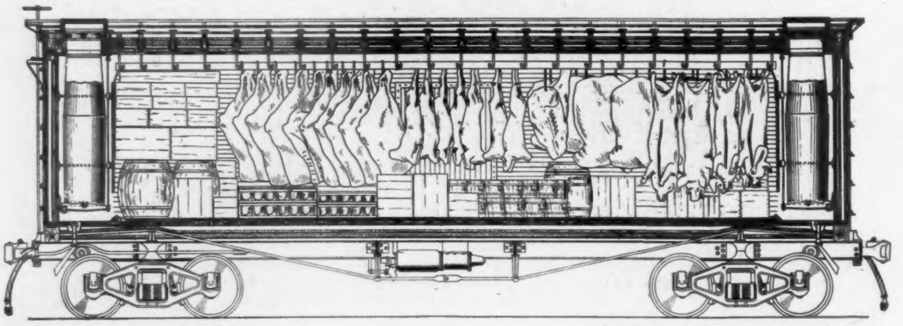
Paradoxical, as it may seem, the low temperatures essential in this industry are almost always the reflex of heat generated in one way or another. And in effecting the sequence of reactions involved the compressor figures conspicuously. Modern cold storage demands a wide range of temperatures, and the compression-system of refrigeration is especially adapted to satisfying these requirements.

Then came the day of the icebox, using natural ice; and the next logical step was the erection of cold-storage warehouses, equipped with large zinc-lined rooms into which tons of ice could be packed for the purpose of chilling contiguous storage compartments. The refrigerating action of the ice was stimulated by the admixture of salt, and in this way the temperature was lowered to or near that of the freezing point. These establishments were designed to take care of the market surplus for the nonce, and they were capable of holding foodstuffs for only short periods. Even so, these warehouses proved a boon; but they were commercially possible only when located within reach of a cheap and abundant supply of natural ice. Finally, they were for the most part local in their influence upon the diet of the populace.

During the time when this system of food keeping was in vogue, the largest cold-storage house in the world was located, so we are authoritatively informed by a Government expert, in the Central West, and boasted a total capacity of 1,800,000 cubic feet of storage space. Then was evolved the modern ice-making machine, which has since brought about a profound revolution in the whole art of cold storage. Large commercial units for mechanical refrigeration were installed in the latter "eighties" and the early "nineties," and from that day on the expansion of the business has been upon an impressive scale.

In 1887, the cold-storage capacity in service in Chicago was short of 3,000,000 cubic feet, and as late as 1902 Greater New York could not claim more than 6,000,000 cubic feet. To-day, Chicago has at her disposal about 60,000,000 cubic feet, and the storage warehouses of Greater New York have cold space amounting to something like 40,000,000 cubic feet. In fact, the growth of cold-storage throughout the entire country has been momentous in the last few years, and the grand total is now approximately 475,000,000 cubic feet, controlled by 1,400 concerns engaged in the business.

Following the development of ice-making machinery came artificial cooling by the ammonia-compression process, and this obviated the need of ice to bring about the desired low temperatures in the cold-storage compartments. That is to say, instead of ice and salt, the ultimate refrigerant was chilled brine circulating through pipes leading from the compressing equipment into the storage chambers. Briefly, the method consists in inducing cold by the alternate compression and expansion of liquid anhydrous ammonia; and the system is based upon the fact that ammonia of this sort vapor-



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The interior of a refrigerator car, showing the ice bunkers at either end and the manner in which the perishable foodstuffs are carried while in transit. The refrigerator car is the indispensable link between the cold-storage warehouse and the more or less remote consumer.

izes at a temperature of—28 degrees Fahrenheit at atmospheric pressure. Water as we know, does not vaporize or boil at atmospheric pressure until a temperature of 212 degrees Fahrenheit is reached.

By the compression system, the gas or vapor obtained from the liquid ammonia is subjected to three operations. To begin, the gas is compressed to a pressure ranging from 150 pounds per square inch upward so that the compressed gas may be liquefied by the cheapest cooling agents such as air and water. The gas is then liquefied by forcing it through coils surrounded by cold water. The water absorbs enough of the heat to bring about the liquefaction of the gas. This condensation constitutes the second operation.

The third step allows the liquefied ammonia, while exposed to a relatively low pressure, to expand and to vaporize—this action takes place in pipes enveloped by a brine mixture. The result is that the vaporizing ammonia absorbs from the outlying brine a measure of heat equal to that previously extracted from the ammonia during the period of condensation and liquefaction. The brine, in its turn, when sent into the cold-storage rooms, readily absorbs the heat contained in substances exposed to its reaction—the brine drawing to it again the heat taken from it by the refrigerating vaporized ammonia. Calcium chloride is commonly employed in the brine solution instead of salt because its freezing temperature is much lower than that of a salt mixture—being 54 degrees below zero.

After the gaseous ammonia has done its chilling work in the expansion coils of the refrigerating machine, it is pumped back to the compressor, and its cycle of usefulness is taken up again. This is repeated continuously. Carbon dioxide is now extensively used on shipboard where ammonia is considered dangerous. The compression process of refrigeration permits of an extremely nice control of temperatures. The ammonia compressors are readily adaptable to the most efficient and economic type of prime movers, that is, the steam engine, direct connected synchronous motor, or oil engine. Because of this range of adaptability the compression system of mechanical refrigeration is the one most widely adopted.

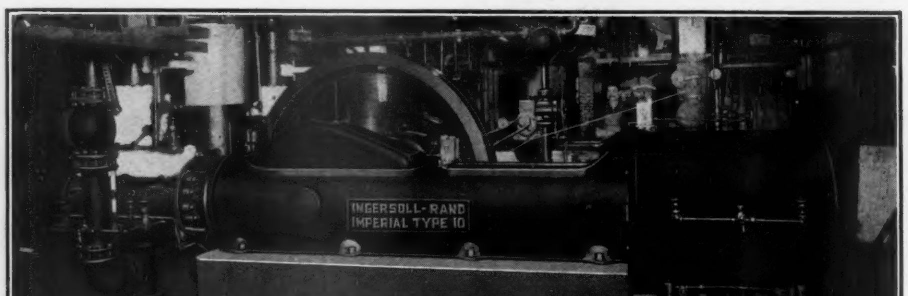
There is another method which is doing good service, i. e., the absorption process. This is based on the fact that certain vapors of low boiling point are readily absorbed by water and can then be separated from the water and volatilized by the application of heat to the mixed liquid. Here, again, the fluid used is a strong combination of ammonia and water. In this system the initial heat is secured by exhaust steam at low pressure, which makes for economy of operation. The gaseous ammonia, when released from the water, is cooled and condensed, thus removing a large percentage of its heat units, and the ammonia so liquefied, when allowed to expand and to vaporize absorbs heat from enveloping brine—this brine is the refrigerant which is pumped thence to the cold-storage chambers. The absorption process is somewhat more complex than a compression plant and calls for more exacting supervision by those in charge of it. Be this as it may, there are a number of cold-storage or freezing installations in existence which have dual equipments consisting of compression apparatus with associated absorption outfits. The point of immediate interest to the public, however, is the fact that engineering cunning in this broad field is working wonders for the commonwealth.

While the classes of foodstuffs which predominate in cold-storage warehouses are meats, poultry, fish, butter, eggs, cheese, apples, seed potatoes, dried and frozen fruits, frozen cream, nuts, rice, and syrups, still there are numerous other commodities that are thus held for marketing and safeguarded the while from spoiling or deterioration. There is a popular and, withal, mistaken conception of the true function of cold storage; and, because of the shortcomings of the practices of other days, the belief persists that comestibles retained in this manner are inferior to the so-called fresh products of the same kind which are offered by the retailer in season.

It goes without saying, that cold storage cannot make a bad commodity good; but it can keep sound goods in an excellent state for a more or less prolonged interval, depending upon their nature. This is achieved by halting or slowing up certain of nature's vital or chemical transformations. The temperatures needed to effect this vary according to the physical peculiarities of the substances handled, and may range all the way from ten degrees below zero Fahrenheit to about 45 degrees above zero.

Commercial refrigeration of the kind under consideration logically divides itself into two departments: one having to do with the preservation and distribution of fresh commodities during a marketing period, and the other involving the retention of seasonal surplusage so that it may be kept fit and offered for sale months later. That is to say, one treatment consists of a chilling which serves to arrest decay and perhaps to inhibit bacterial activity, whereas the second is of such an order as will protect the commodities for a much longer while from actions likely to alter their value as foodstuffs. In the trade, comestibles of the first group are called "fresh," and those of the second class are known as "cold-storage" products. This does not mean, even so, that the latter goods are necessarily less desirable. And now let us be specific and see just what cold storage, in its broadest sense, does for us.

We have in the United States herds totaling 24,000,000 cows, and in the course of a year these animals furnish us about 90,000,000,000 pounds of milk, i. e., 10,400,000,000 gallons. In round figures, 40 per cent. of this milk is devoted to the manufacture of butter, about 43 per cent. is consumed in the household, and the remainder is worked up into cheese, various forms of canned milk, oleomargarine, milk chocolate, ice cream, etc. The best and most of the butter is produced when the pastures are fresh and the grass youngest and greenest. Therefore, the bulk of our butter is churned within a comparatively short interval of the growing season. But for cold storage this



Steam driven ammonia compressor at Runkel Brothers, manufacturers of cocoas and chocolates in New York City. This compressor is an example of the application of high economy steam drive to ammonia compression machines.

Preserving a Variety of Foodstuffs in Cold Storage

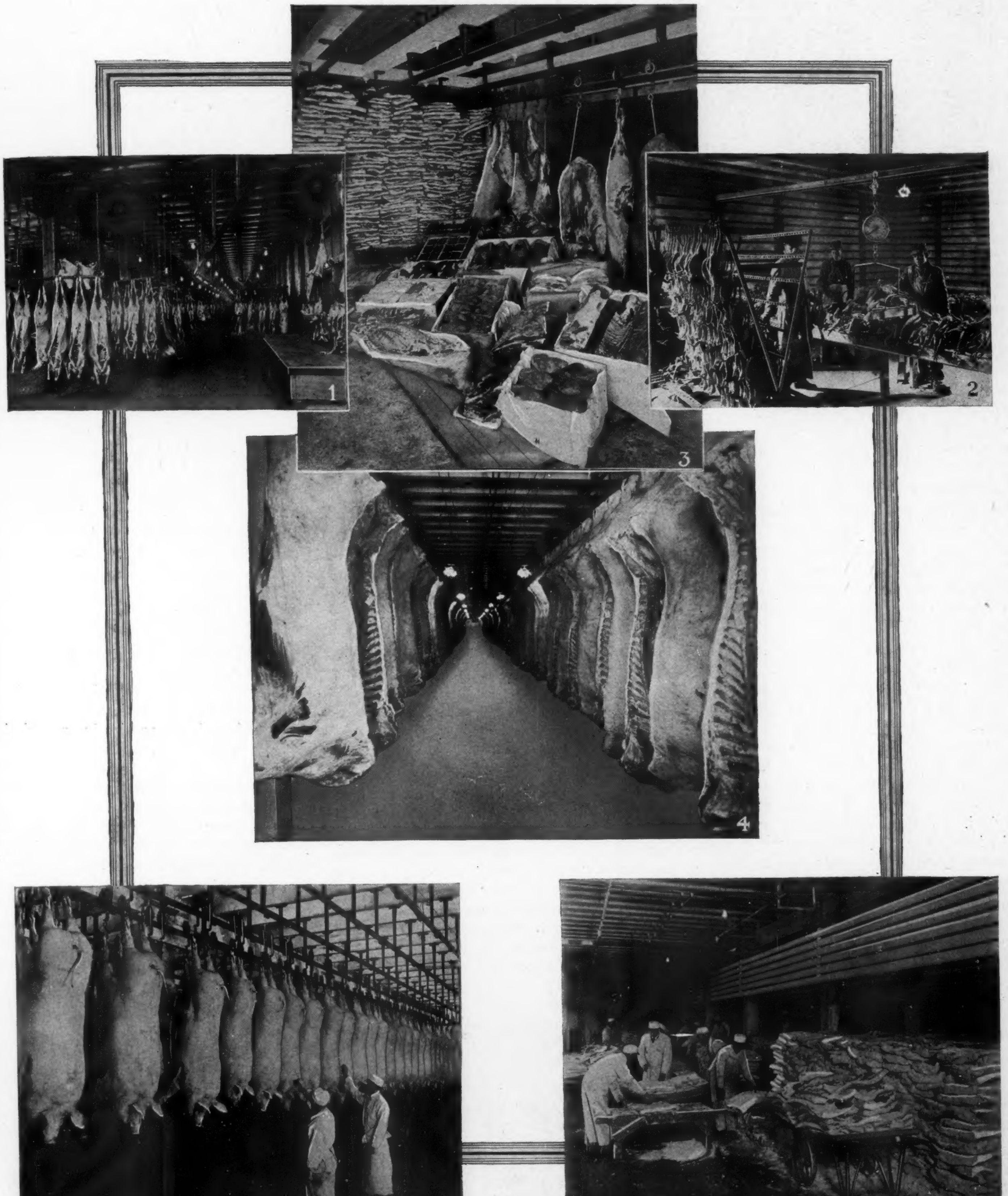
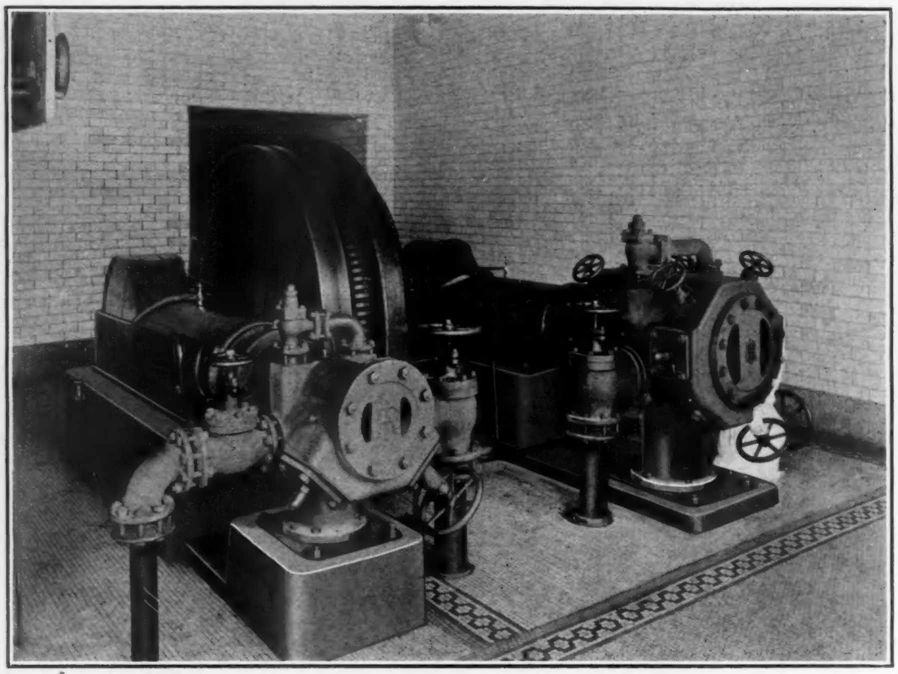


Fig. 1—The interior of a big sheep chill room. The preparation and dressing of sheep and lamb for the cooler call for some 50 operations, but, even so, one large packing plant can handle some hing like 700 sheep per hour. The gravity trolley system in refrigerating and packing plants does much to facilitate this work. Fig. 2—Grading poultry from a hanging rack in a naturally-lighted, mechanically-refrigerated packing room. Fig. 3—An array of foodstuffs, including meats, lard, poultry, and berries, which are being held fresh for the market in cold storage. Fig. 4—The beef cooler of a large packing plant which has a capacity of 3,000 sides of beef. Here the meat is held at a chilling temperature of 38 degrees Fahrenheit. Fig. 5—After having passed four inspec ions the hog carcasses are stamped "U. S. Government Inspected" and left to chill in the cooler at a temperature of 38 degrees Fahrenheit until marketed. If the hog is to be cut up for pork products it is left in the chilling room for 48 hours or until all of the animal heat is extracted. ***Fig 6—A cooled curing cellar of one of our packing plants where meats are treated with dried salt under Government inspection.***



Two-stage ammonia compressor installed at Colonial Ice Cream Company, Philadelphia, Pa. Here the rotor of the synchronous motor is direct-connected to the shaft of the compressor.

bounty could not be put away and brought out subsequently to supplement the naturally much reduced supply of fall and winter. It may be of interest to know that though comparatively little butter is held in cold storage more than six or eight months, still butter has been so kept for three years and then found to be in an excellent state and of a high degree of palatability. Such was not the case when butter was salted down and packed away in firkins before cold storage made it possible to spread our bread in winter with the delicious butter of the springtime. For the sake of those interested in statistics, the total annual output of butter is in the neighborhood of 1,600,000,000 pounds; and the largest amount held in storage at any time is seldom more than 100,000,000 pounds, i. e., a little more than six per cent.

The hens of the country, in a twelvemonth, lay 2,500,000,000 dozen eggs; and in dealing with this commodity we have much the same condition as that prevailing in the butter trade. Naturally, eggs are a perishable foodstuff and especially seasonal in their maximum yield. By far the greatest number and the finest of the eggs are laid during the months of April, May and June, and these are the eggs that are put in cold storage and marketed mostly during the fall and winter. Eggs of this sort, when properly selected and chilled, are commonly superior to the fresh eggs sold in the latter part of the summer and the early autumn. The problem is to keep the eggs at a temperature of about 34 degrees Fahrenheit so as to arrest the vital processes and to avoid freezing them the while. If a freezing temperature were employed crystals of ice would form and penetrate through the yolk and the white, and thus cause these two normally separate elements of an egg to run together.

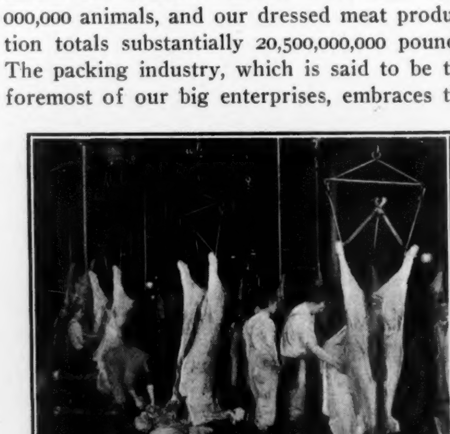
Putting ice and salt into a refrigerator car. The salt is added whenever a temperature below 40 degrees Fahrenheit is required.

The eggs of any year are seldom held after March of the succeeding one; and, as a rule, the maximum quantity of eggs in storage does not exceed ten per cent of the total annual production. Thanks to cold storage, spring eggs are fit for poaching or boiling after being kept for six months, and they are wholesome when used in other ways at the end of nine months of refrigeration. So far, we have discussed only eggs in the shell. A considerable percentage of eggs, which formerly represented a loss of approximately $50,000,000 yearly, is now conserved through the medium of freezing. These eggs, with cracked or broken shells, are removed from their shells, placed in buckets or other containers, and frozen solid at a temperature of about ten degrees below zero. In this condition, the eggs can be held for a long while; they take up less space than the regular eggs in cases; are not so liable to injury during distribution; and are admirably adapted to the requirements of bakers and confectioners. Our cakes and pastries are all the more tempting because these thoroughly good eggs are available at a moderate price.

The subject of eggs naturally brings us to the allied one of poultry. The annual production of poultry is about 600,000,000 head or approximately 1,700,000,000 pounds, and our daily consumption is said to be more than 4,500,000 pounds. Again, we have to a marked degree a seasonal commodity; and to take care of this and to effect a gradual distribution from month to month thereafter it is necessary to carry the poultry for a more or less protracted interval under refrigeration or cold storage. Poultry, as might be expected, is variously classed. The Southern farmer sells his stock earlier, because he does not have the grain with which to feed his chickens, and therefore does not hold them so that they may mature. Broilers are stored during July, August and September, and the fryers are put away during September, October and November. Farther North, where grain is grown, the farmers keep their flocks until they are bigger and reach the stage known as roasters, and these are stored during October, November and December. This stock is not retained after the first of September of the following year while the broilers are marketed earlier—not later than June first.

To freeze poultry, a temperature of from fifteen to eighteen degrees Fahrenheit is required, and thereafter the goods can be kept in storage at a temperature of from 25 to 28 degrees Fahrenheit. A great deal of poultry is marketed fresh, i. e., it is held under refrigeration from a week to a month—preferably not more than two weeks. This is accomplished by chilling the stock to about 30 degrees Fahrenheit. Success in this business hinges upon the promptness with which the killed chickens are passed into the refrigerator; their condition at the time of reception; and the care taken in handling them. Tremendous strides have been made in these particulars in the last few years; and much of the advance is due to the scientific investigations instituted by the U. S. Department of Agriculture.

What has been previously remarked of poultry and eggs is equally true of meats. Next to the people of Australia, Americans are the greatest eaters of meat, and the annual per capita consumption here is 186.5 pounds, made up as follows: mutton and lamb, 6.4 pounds; beef and veal, 80 pounds; and pork, including lard, 100.1 pounds. In the course of a twelvemonth our abattoirs handle more than 100,000,000 animals, and our dressed meat production totals substantially 20,500,000,000 pounds. The packing industry, which is said to be the foremost of our big enterprises, embraces the



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Dressing cattle in a packing plant. So rapidly is this work done that less than 39 minutes are required to change a steer from a living animal into food.

Thousands of cases of highly perishable strawberries, raspberries, etc., are bought by the canners in times of plenty and then sent by them to the cold storage warehouse for keeping until the factories are able to preserve them.

operation of nearly 900 plants; and without exception refrigeration is indispensable to their successful functioning, whether this be for chilling or freezing meats or for the better preservation of these commodities when cured, pickled, etc.

As may be understood, cattle, sheep and hogs, are generally slaughtered when in prime condition, and this is contingent upon the seasonal food supply. Therefore there are periods during the spring or warm months of every year when the greatest number of these animals reach the stockyards of the packers. No wonder, then, that some of these concerns have individual cold-storage facilities with capacities up to 5,000,000 or 6,000,000 cubic feet. In this way, the incoming meat of the abundant months can be absorbed and retained for regulated distribution throughout the intervals of lessened production. At no time, so it is reported, is more than ten or twelve per cent of the entire annual supply held in cold storage. This is because chilled meats in large quantities are being continually issued and sent broadcast to gratify our palates and to amplify the diets of the peoples of other nations. The keeping temperatures vary with different kinds of meats and meat products; and in a well-regulated plant the degree of cold can be maintained within a range of two degrees above or below a prescribed point.

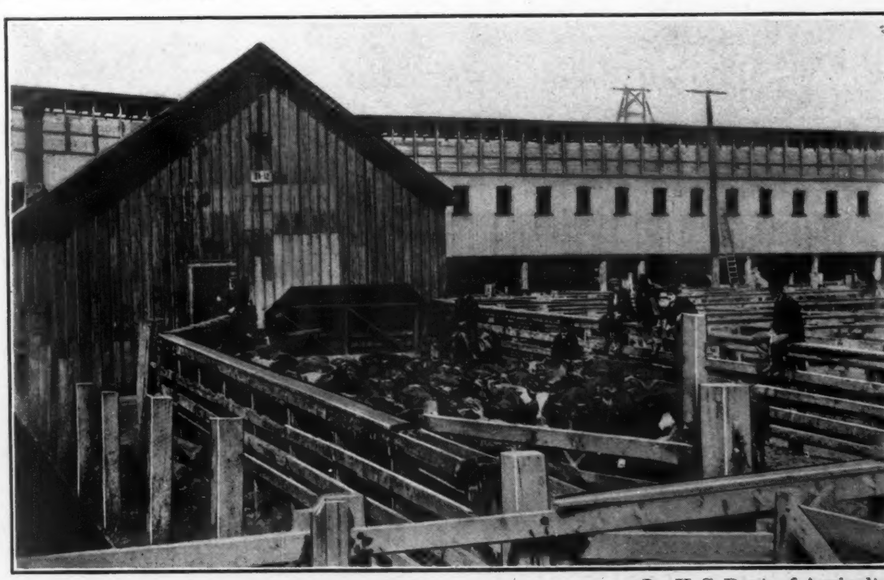
Probably no department of cold storage has a more promising future than that devoted to the handling of fish. This business has grown enormously in the last few years and is a striking example of what refrigeration can do in the way of preserving a notoriously perishable type of foodstuff. In the course of a twelvemonth we draw from our waters a total of quite 2,400,000,000 pounds of fish. But for the aid offered by cold storage there would be markets for only a small portion of this foodstuff, and these would be restricted to zones lying within a short radius of the fishing centers. Fish packed in ice—assuming that a plenty of low-priced ice be available, can be shipped inland from the receiving stations probably not more than 700 or 800 miles. In warm weather it is doubtful if they could be dispatched that far and be found tempting to the palate by the time they reached the consumer.

But when fish are taken fresh from the water, promptly chilled, and then subjected to freezing, they may be distributed in the latter state, in refrigerator cars, anywhere within the boundaries of the United States and Canada. It may not be common knowledge, but 90 per cent of all the fresh halibut eaten in this country is obtained off the coast of Alaska, quickly frozen, and then shipped overland to the markets. In a similar way large quantities of fresh salmon are caught on the West coast and sent across the continent; and before the World War our frozen fresh salmon was eaten extensively in the countries of Western Europe, where it brought profitable prices. This is in direct contradiction to a persistent and erroneous belief that frozen fish are flat in flavor and far less desirable than the so-called fresh commodity. Once more we shall see that satisfaction to the consumer is dependent upon the care and the means employed to preserve the fish between the moment of its taking and its appearance upon the table.

The catching of fish is a peculiarly seasonal industry, and the great bulk of the different kinds is landed within decidedly short periods in each year. These range from a span of two weeks to a matter of a couple of months, and "when the run is on," the fishermen must work early and late in order to garner the biggest possible catch. Therefore, the freezers have their times of feverish activity; and it is necessary that the refrigerating equipments be such as will facilitate the treatment of scores and scores of tons of seafood in the course of 24 hours. Naturally, a very considerable percentage of these fresh fish are refrigerated and dispatched to the markets soon after they have come out of the water, but enormous quantities are held to be sold long after the fish have disappeared from the fishing grounds or when wintry storms prevent the fishermen from following their accustomed calling.

The fish industry is probably more complex than any other of our food producing businesses, for it involves the handling of more than 70 kinds of fish, caught in waters of varying temperatures, ranging from the warm flood of the Gulf of Mexico and Florida to the icy tides of Alaska. These are taken at different seasons and by divers methods; and the fish so gathered by traps, seines, or lines weigh anywhere from 1,000 pounds, in the case of the albicores, downward to the tiny white bait of less than one-half inch in length. There are halibut from ten to 250 pounds; salmon of several sorts tipping the scales at from six to 50 pounds; there are cod and other ground fish that will average from two to 40 pounds; and, besides, there are the commonly more moderate-sized species like lake trout, whitefish, bluefish, weakfish, mackerel, etc. Strange as it may seem, the shape and the size of a fish are factors that govern to no inconsiderable extent the method pursued in effecting its freezing.

Frozen fish, to be equal in food value and flavor to freshly caught fish, must be placed with all practicable dispatch in the freezing



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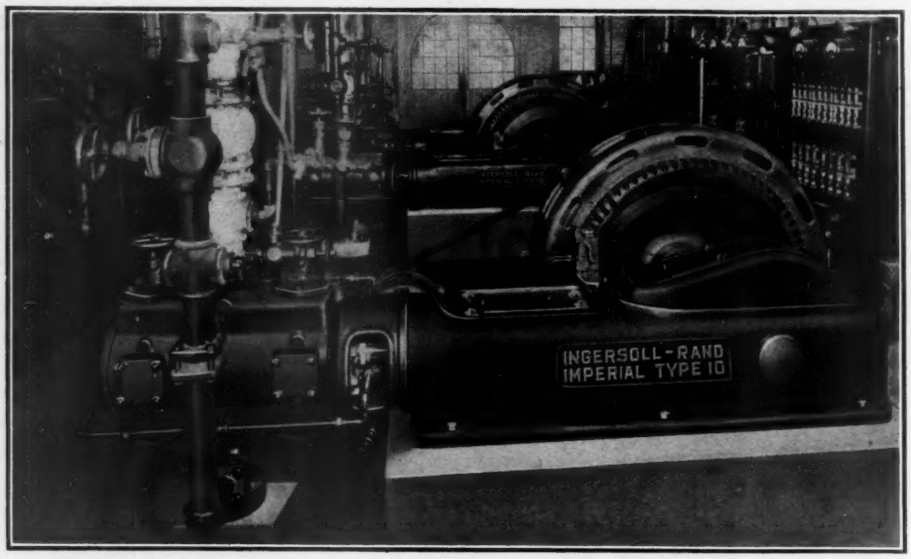
Ante-mortem inspection of cattle which is made upon receipt of livestock. This is the first of the four Government inspections to which cattle are subjected before they finally reach the cooler.



Several direct-connected motor driven ammonia compressors serving a large ice-making plant.

rooms. It is essential that the fish be handled as little as possible inasmuch as any bruising, breaking of the skin, or damage to fins will either lower their keeping properties or lessen their attractiveness when offered for sale. Further, the fish should not be allowed to become warm between the time they are caught and their entry into the freezer, because changes in the flesh take place which no amount of freezing will offset. It is not permissible here to detail the numerous steps pursued in preparing fish for freezing. It will suffice for the present purpose to say that, according to the size of the fish, they are frozen either singly or in "lots"—"sharp freezing" being accomplished at a temperature of from five to fifteen degrees below zero Fahrenheit. It is true, that fish can be frozen at temperatures well above zero, but this is undesirable and reduces the flavor and palatability of the commodity. Let us explain.

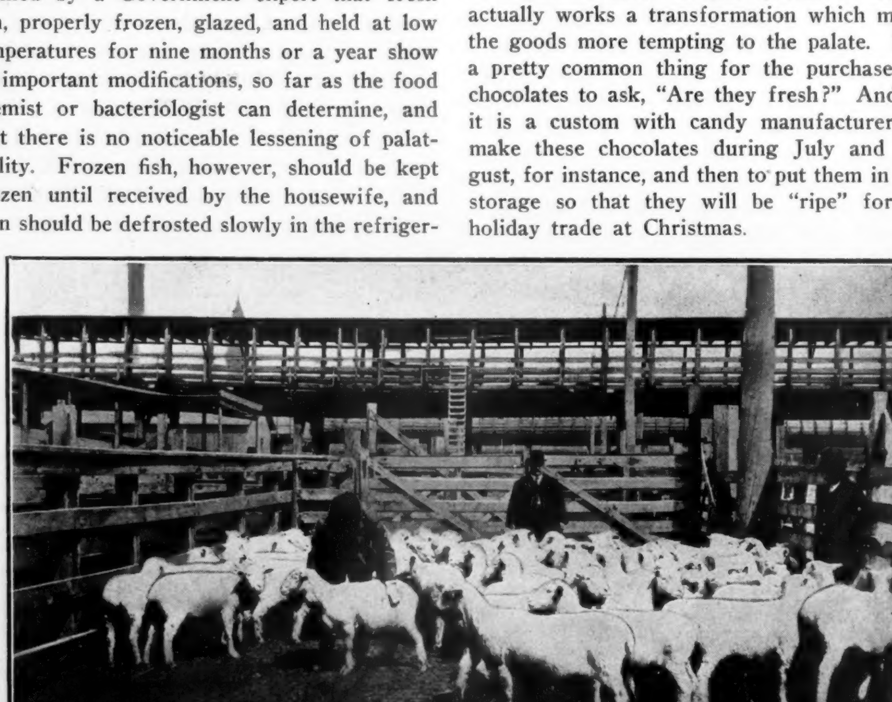
At temperatures above zero, the fish is frozen through more slowly, and by reason of this the body fluids are given time in which to form into comparatively large crystals. These crystals break down the tissues. Therefore, when the fish is thawed out the melted juices escape and the meat becomes soft, relatively dry, and deficient in taste. Sharp freezing, on the other hand, induces only minute crystals of ice, and these are not of sufficient size to injure the flesh or muscle fibers. Consequently, when defrosted, the fish is full flavored and much more pleasing to the taste. Here we see one of the outstanding advantages following upon the employment of temperatures below the zero point. But this initial freezing is only one of the steps in the preparation of fish for cold storage.

The ultimate market value of a cold-storage fish is determined by the closeness of its resemblance to one of its kind just caught. That is to say, the color of the gills should be pinkish or bright, the cornea should be transparent, the eyes clear and bulging, the skin shiny, the flesh firm, and the mouth and gills closed. To retain these tell-tale signs of the fresh denizen of the deep, the frozen fish is subjected to a glazing process. This consists in dipping the frigid fish for a moment into a bath of cold water so that the film of clinging water is instantly converted into a veneer of clear ice. Successive dippings add to the thickness of this protective coating—the thicker the glaze the longer a fish can be held in storage without impairing its appearance and food value. It is sometimes necessary to reglaze fish during the holding period, because the ice evaporates in time even though it does not melt; and if fish become uncovered their body fluids also evaporate and the tissues undergo changes which alter the flavor and the marketability of the commodity. We are authoritatively informed by a Government expert that fresh fish, properly frozen, glazed, and held at low temperatures for nine months or a year show no important modifications, so far as the food chemist or bacteriologist can determine, and that there is no noticeable lessening of palatability. Frozen fish, however, should be kept frozen until received by the housewife, and then should be defrosted slowly in the refrigerator. Treated in this manner the fish will be found delicious.

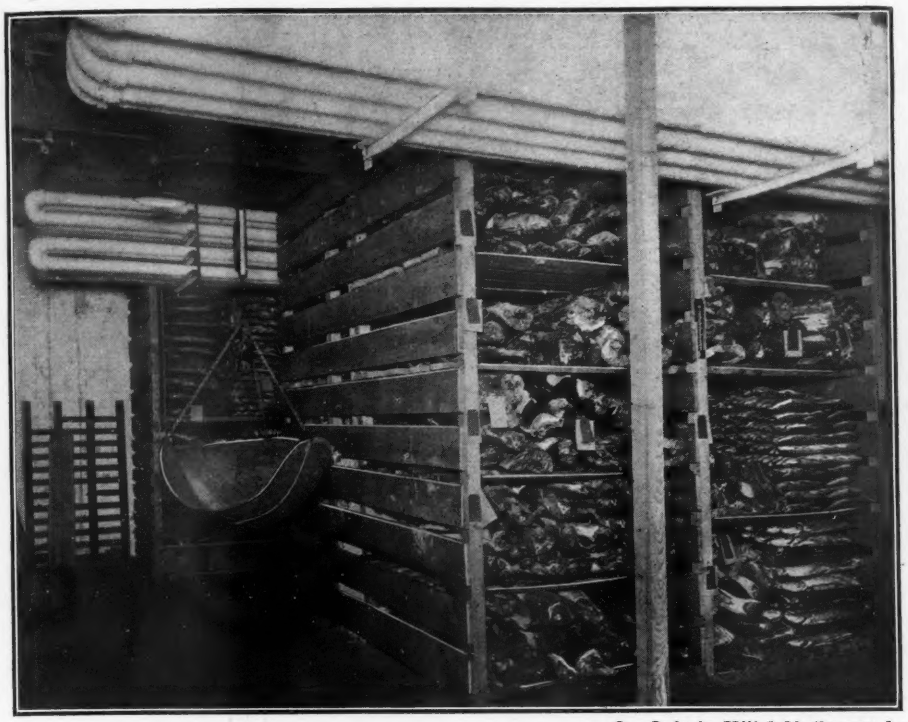
Only a brief reference can be made to the part played by cold storage in preserving fruits and vegetables so as to effect their distribution to widely scattered markets—thus unifying the fare, so to speak, of the entire nation. It is in this way that the luscious citrus fruit, pineapples, grapes, melons and choice early vegetables of the warmer sections of the country find their way into the colder and more densely populated areas. Conversely, the sturdier apple and other foodstuffs of the Northern soil are dispatched southward and held for consumption despite adverse climatic conditions.

The factors affecting the keeping of fruits and vegetables by freezing storage, at temperatures ranging from five degrees to twenty degrees Fahrenheit, have been investigated; and berries, plums, cherries, beans, sweet corn, etc., have been submitted to this line of research. The conclusion is that a more extensive utilization of this type of refrigeration seems entirely practicable and desirable from an economic point of view in large market centers where surplus stocks of a highly perishable nature are dealt with. That is to say, the intermittent excess, instead of going to waste, can surely be saved and made available later for consumption. In short, a loss can be turned into a profit.

America's sweet tooth is satisfied annually at an expenditure of many millions of dollars; and it will probably surprise a good many persons to learn that a great deal of the candy consumed has first to pass through a period of cold storage before it is ready for sale. That is to say, the problem is not merely one of preserving the confectionery until the day of a rush demand, but this system of keeping actually works a transformation which makes the goods more tempting to the palate. It is a pretty common thing for the purchaser of chocolates to ask, "Are they fresh?" And yet it is a custom with candy manufacturers to make these chocolates during July and August, for instance, and then to put them in cold storage so that they will be "ripe" for the holiday trade at Christmas.



Inspecting sheep at the stockyards of a packing plant. The animals that are suspected of being diseased are marked for special post-mortem examination.



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Unboxed frozen fish in a cold-storage chamber As can be seen, the fish are of several varieties ranging from the large salmon to the smaller or frying varieties.

The stay in storage serves to mellow and to cure the confections. The chocolates when first prepared are so hard that a hammer would be needed to crack them. After they have been in cold storage for about three months they are then in just the right condition and in that softened creamy state which is generally understood to represent freshness. Some cold-storage establishments thus handle hundreds of thousands of pounds of candy.

Cold storage plants, by themselves, would not solve the whole question of food conservation and price stabilizing; these warehouses may properly be likened to the part played by the heart in the circulatory system of the body. The arteries and veins of the food supply system are the highly developed refrigerator cars which are the mediums employed to keep perishable commodities in cold storage while effecting their distribution over varying distances—some of these measuring thousands of miles. By these agencies the entire nation is unified so that foodstuffs may move freely from one end of the country to the other and all of us have at our disposal a kindred or similar bounty. Refrigerator cars, and there are thousands and thousands of them, are of divers sorts.

In many of them, refrigeration is accomplished by means of ice and salt packed in bunkers or compartments at each end of a vehicle. Cars of this sort are really only modified forms of the domestic icebox. Engineering ingenuity, however, has devised other types which are far better suited for long runs and for maintaining the low temperatures of cold-storage establishments. Cars of this character are equipped with either absorption or compression-refrigerating apparatus; and thus the cold-storage warehouse is, in effect, put on wheels so that it may be drawn anywhere within reach of the railways.

Finally, the cold-storage ship is capable of widening the radius of distribution and tapping any clime and touching any port situated upon the borders of the Seven Seas. To-day, in this way, California is sending to our Atlantic seaboard, via the Panama Canal, large quantities of its luscious fruit and tempting vegetables; and there has recently been put in service the first of a fleet of large freighters which, with cold storage capacities of 3,000 tons apiece, are to maintain the fruit traffic between our Western coast and Europe. All of these craft are provided with refrigerating machinery of the compression type.

Enough has been said to make apparent the general utility of cold-storage, using the term in its widest sense; and all of us should now realize how artificial refrigeration is working wonders in spreading the plenty of the bountiful seasons over a whole twelvemonth. But this is not the whole story. It should not be forgotten that the population of the nations is multiplying steadily, and that there is a continual tendency towards concentration in industrial centers. Therefore, there are more and more mouths to be fed within areas where the production of food dwindles proportionately. This economic movement would certainly prove fatal, starvation would face millions of us, but for the compensating relief afforded through the cold-storage warehouse and the refrigerator car. These instrumentalities are bound to be of increasing benefit.

BRITISH AIR LIFT PRACTICE

AT THE LATEST meeting of the British Association Dr. John S. Owens presented an interesting paper dealing with air lift pumping, his object being rather to call attention to the possibilities of the air lift than to indicate any final conclusions as to best design and application.

He had made some experiments with the object of producing the best pump for lifting acid mine liquors in the mine of San Domingos, in Portugal. The work that had been done convinced him that the low efficiencies usually obtained were not an essential part of the method, and he had been able to get pump efficiencies with air lifts of between 60 and 70 per cent.

Causes of loss in air lift pumps could be grouped under the following heads:—(1) Slippage losses, due to relative motion between air bubbles and water; (2) losses due to friction of the mixture of air and water in the rising main; (3) friction losses incurred by the flow of water before air was admitted; (4) energy discharged in the kinetic form with the water and due to the velocity of discharge.

The losses under headings (3) and (4) were definite quantities and could be said to be more or less under control. It was in connection with those under (1) and (2) that there appeared to be a good opportunity for increased economy.

Many experiments had been made already dealing with the question of submergence, and it had been definitely established that there was a most suitable value for this, the best efficiency being obtained with a submergence of about 70 per cent, that was when the length of submerged pipe was 70 per cent of the total length—submergence + lift.

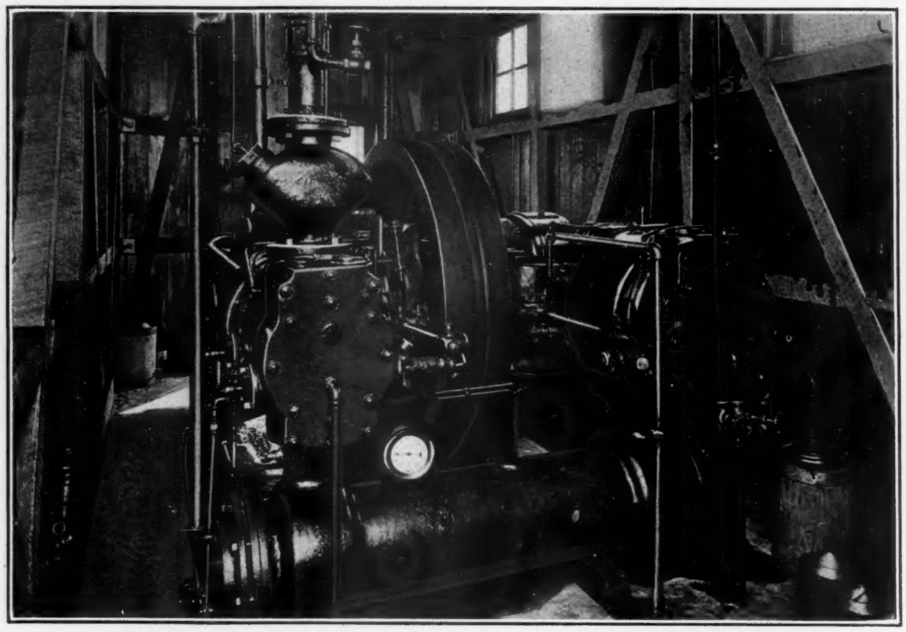
With regard to the loss arising from slippage, it was clear that a high velocity of the mixture tended to a low slippage loss. The loss due to friction of the mixture in the eduction pipe was often considerable. It varied directly with the square of the velocity, while those from slippage varied inversely with the velocity, and the aim of the designer was to fix a definite value for the velocity where the sum of the friction and slippage losses would be at a minimum. It was a well-established characteristic of air lift pumps that the highest efficiency was obtained at one particular delivery. The most suitable value for the submergence was best found experimentally, but seemed usually to be between 65 and 75 per cent. An appreciable effect was, however, to be obtained by very small variations in submergence. Taking v as the mean square of velocity in the pipe and f as the coefficient of friction, tests gave a value of $f = 0.025$ in a 6⅝-in. pipe with v mean $= 13.3$. The effect of nozzle diameter was found to be very slight, the governing factor being the rate of flow of air through the orifice. Describing the air lift mine pump, the author said that the installation was in two lifts—one of which raised the water from the 210 m. to the 180 m. floor, and the other raised the water to the 150 m. floor. It was found that the efficiency of the upper lift pump varied between 56.6 and 64.13 per cent, and that of the lower lift pump from 52.5 to 66.1 per cent. The throat piece with the smallest diameter was found to give the highest efficiency—a result which was somewhat unexpected. The probable explanation was the effect on the size of bubbles. The smallest throat yet tried had a diameter of 3½ in., and this was being experimentally reduced to 2½ in. This installation had replaced a three-throw electrically driven ram pump which had been a constant source of trouble.

LARGE PORTABLE COMPRESSOR FOR BRIDGE WORK

By L. F. KUHMAN

THE AMERICAN Bridge Company has recently placed in operation a new compressor car completely equipped, on one end of which is a 90 horse power oil burning boiler made by the International Boiler Works, a 60 gallon oil tank and an air receiver, and on the other end a 446 cu. ft. Ingersoll-Rand steam driven air compressor. The car is used by the erecting department and is moved from job to job as required, and at present is being used on the new Southern Railway bridge crossing the Ohio river at Cincinnati.

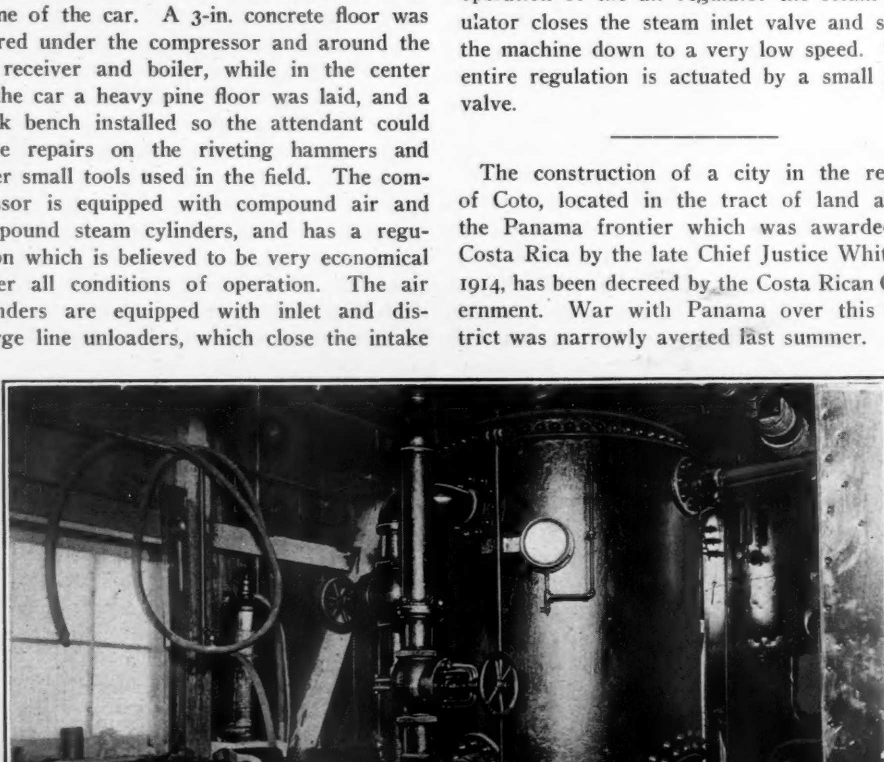
When the compressor car was first considered much thought was given to the method of drive, as to whether it should be electric or steam. The latter was finally selected because it could be used on a maximum number of operations, as usually water is easily obtained for the boiler, while if a motor drive were used, current obstacles would be encountered due to electric current varying greatly throughout the country, and is sometimes very difficult to obtain, even if the proper current is carried near the operation.



Interior view of the car showing a steam driven air compressor of 446 cu. ft. capacity mounted at one end.

The equipment was placed on a steel frame flat car and a special housing built around it. The compressor is bolted to 24-in. "I" beams, and the "I" beams in turn riveted to the main frame of the car. A 3-in. concrete floor was poured under the compressor and around the air receiver and boiler, while in the center of the car a heavy pine floor was laid, and a work bench installed so the attendant could make repairs on the riveting hammers and other small tools used in the field. The compressor is equipped with compound air and compound steam cylinders, and has a regulation which is believed to be very economical under all conditions of operation. The air cylinders are equipped with inlet and discharge line unloaders, which close the intake and open the cylinders to atmosphere when any predetermined air pressure has been reached in the receiver, thereby allowing the machine to run idle. Simultaneously with the operation of the air regulator the steam regulator closes the steam inlet valve and slows the machine down to a very low speed. This entire regulation is actuated by a small pilot valve.

The construction of a city in the region of Coto, located in the tract of land along the Panama frontier which was awarded to Costa Rica by the late Chief Justice White in 1914, has been decreed by the Costa Rican Government. War with Panama over this district was narrowly averted last summer.



Showing the air receiver and the work bench for repairing field tools.

EMPTYING OIL BARRELS BY COMPRESSED AIR

A LETTER IN a recent issue of *Power* describes a device for emptying barrels of oil by the compressed-air process. The writer states that with 4 lb. pressure a barrel of engine oil could be emptied in seven minutes, forcing the oil to an elevation of eight feet.

A dead-weight safety valve to avoid excess pressure was made by turning the threads off the stem of a ¾-in. angle valve and securing sufficient weight to the valve wheel to balance a 4-lb. pressure. This valve was placed in the air line between the barrel and the air-supply valve, which, for ease of control, should not be larger than ¼-in. If for any reason the oil did not flow readily from the barrel, the safety valve prevented the pressure building up. The small opening of a ¼-in. valve was sufficient to elevate the oil rapidly.

In elevating cylinder oil in cold weather, the barrel was moved to a warm place for two or three days before unloading to get the oil more limpid. It usually required from 30 to 40 minutes to empty a barrel of average cylinder oil.

The ordinary oil barrel will safely withstand 4 lb. pressure, and after a little experimenting with the amount of opening necessary to give the air-supply valve, one can connect up the apparatus, turn on the air and go about other work without any danger of a burst barrel. When the oil is all out of the barrel, the slight blow of air through the discharge pipe will indicate it, and no damage will be done if no one is near to shut off the air.

Production of locomotives and railway cars in Soviet Russia by the 21 factories engaged in this work showed a considerable decline for the first six months of 1921, as compared with the latter half of 1920, the contributing causes being lack of provisions and scarcity of fuel, as stated in a report from Consul Leslie A. Davis, at Helsingfors, Finland.

The Tailing Air Lift of the Chino Copper Co.*

Recently Developed Plant Capable of Raising Over 12,000 Dry Tons Per Day a Distance of 40 Ft. Exceeds Expectation, Saving 50 Per Cent of the Operating Cost of Bucket Elevators

By H. G. S. ANDERSON
Assistant General Manager, Chino Copper Co., Hurley, N. M.

THE AIR LIFT has been receiving increased attention recently in the metallurgical and chemical industries, owing to its simplicity and reliability. It is somewhat of a paradox, however, that the very factors which are strongly in its favor are often the indirect cause of its being condemned. The most important of these factors is the presumption that it requires too great an amount of power compared with other types of pumps and elevators often used for the same service. This impression is commonly traceable to the fact that the simplicity of the system has made it possible for many installations to be made without a sufficient knowledge of the important details necessary for efficient operation.

It is not my intention in this article to contend that the power consumption of the air-lift system is less than, or even equal to, that of other systems for the same service. The following description of results achieved should, however, be of great interest to millmen having similar problems, as the data are taken from a plant which is probably the largest of its kind in operation and which was designed to keep the power costs as low as possible, as well as for the purpose of obtaining continuity of service and freedom from excessive repair costs.

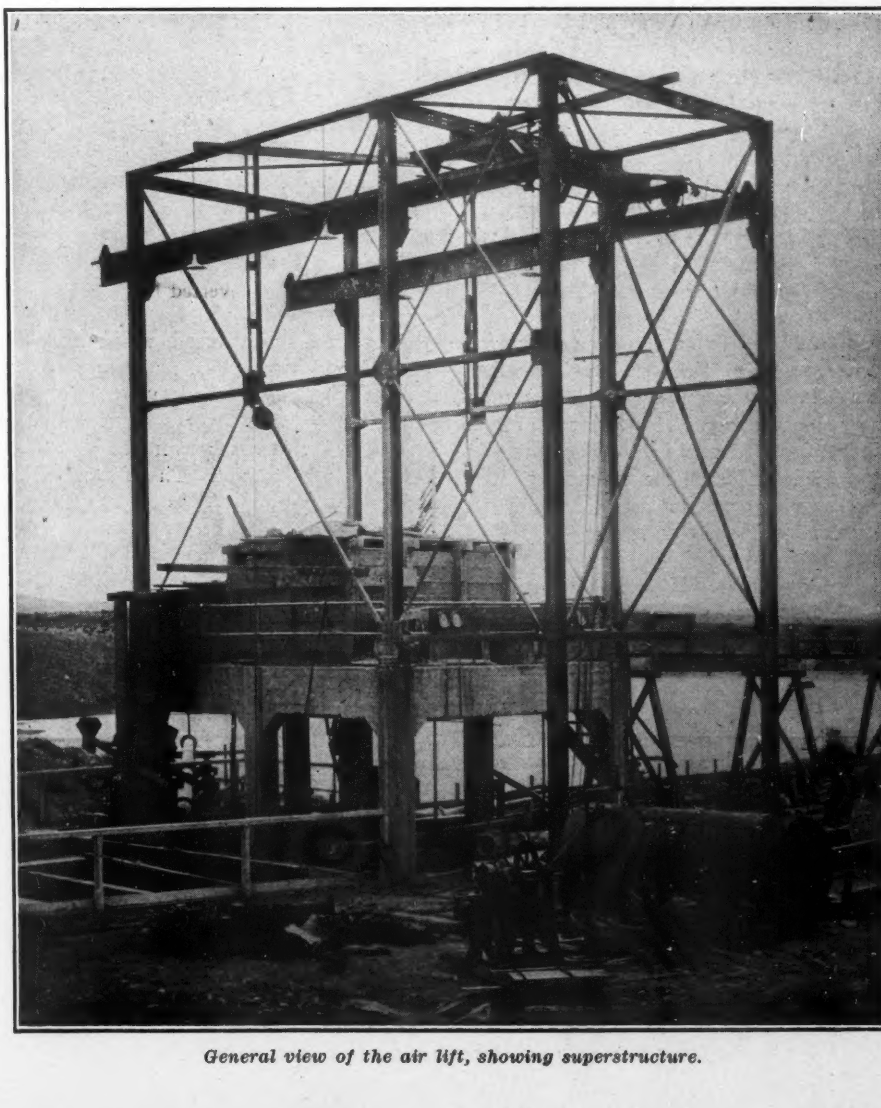
During 1918 a bucket-elevator plant was designed to elevate the tailing discharge from the concentrator of the Chino Copper Co. at Hurley, N. M., a height of approximately 40 ft., to transport this tailing through launders to an area where additional tailing disposal space was available. Construction work was begun and a large pit was excavated to provide for a sufficient number of bucket elevators to elevate a maximum of 12,000 tons of tailing daily. Concurrently with this preliminary construction work, the theoretical and practical considerations involved in an air lift to elevate the same amount of tailing were discussed. The problem of tailing disposal was one destined to become increasingly important throughout the life of the mill, and it was decided to investigate carefully the economical possibilities which the air lift offered, before construction of the bucket-elevator plant had progressed too far. Cost data covering the operation and records of bucket elevators handling the same class of material were available from past operations.

The air lift seemed to be a radical departure from current practice, but the final estimate of the probable cost of operation indicated that a sufficiently large saving would be made to justify the installation of the air-lift plant instead of the bucket elevators. The air-lift installation would also be of considerable experimental value for future use, as successful operation might indicate that it would pay to abandon elevators for future installations in the mill and perhaps replace some of those already in use.

The final cost of the air-lift plant, as it stands on the construction accounts, is the same as the estimated cost of the bucket-elevator plant, for the reason that the site already selected was used for the installation of the air-lift plant, and all of the initial construction costs, primarily chargeable to the partly finished bucket-elevator plant, were charged against the air-lift installation. If the advisability of using an air lift had been more apparent when construction work was begun upon the bucket-elevator plant, the tailing air-lift site would have been changed to a location more favorable to that type of installation, and the original estimate of 75 per cent of the cost of the bucket-elevator plant would have been more nearly approached.

Comparative estimates of the bucket-elevator and tailing air-lift plants to handle the 12,000 dry tons of tailing daily indicated that the first cost of the air-lift plant would be approximately 75 per cent of the first cost of the bucket-elevator plant, and that the cost of operation of the tailing air lift would amount to approximately 72 per cent of the cost of operating the bucket-elevators. The advantage, from all points of view, indicated the desirability of installing air lifts instead of bucket elevators.

The air-lift plant was installed and placed in operation in July, 1919. During July and August of that year extensive tests were carried on to determine the most economical operating



General view of the air lift, showing superstructure.

*Reprinted from "Engineering and Mining Journal."

TABLE I. ESTIMATE MADE IN 1918 ON BASIS OF 12,000 DRY TONS' DAILY CAPACITY

Plant	Estimated Life Twenty Years. Tons Elevated in Twenty Years	Estimated Operating Cost per Dry Ton	Estimated Operating Cost per Year	Estimated Total Operating Cost
Elevators.......	87,600,000	$0.011756 (*a*)	$51,491	$1,029,825
Air lift.........	87,600,000	.008483	35,980	719,612
Estimated saving..............		$0.003273	$15,511	$310,213

(*a*) Actual cost of elevating the same class of material by bucket elevators previous to 1918.

TABLE II. BASED ON ACTUAL AVERAGE TONNAGE OF 5,000 DRY TONS DAILY FOR SIXTEEN MONTHS

Plant	Tons Elevated in Sixteen Months	Actual Total Operating and Repair Cost, Sixteen Months	Actual Cost per Dry Ton Elevated	Equivalent Cost per Year at Full Capacity	Estimated Operating and Repair Cost, Twenty Years
No. 3 elevator (*a*)....	2,459,300	$48,078.47	$0.01954	$85,585.20	$1,711,704
Air lift......	2,207,922	21,798.90	.009873	43,243.74	864,874
Actual saving			$0.009667	$42,341.46	$846,830

(*a*) Actual cost of operation and repairs of elevators elevating the same material substantially the same distance in the mill of the Chino Copper Co.

conditions, the efficiency that could be obtained, and such other useful information as might develop. During the succeeding sixteen months, from September, 1919, to December, 1920, inclusive, accurate costs were kept on the operation of the air-lift plant and on a bucket-elevator plant operated under practically the same conditions of lift and capacity, in the mill itself.

Table I illustrates a comparative estimate that was made in 1918 on a basis of 12,000 dry tons' daily capacity, and Table II the actual comparative costs based on an average capacity of 5,000 dry tons daily for the sixteen-month period beginning September, 1919, and ending Dec. 31, 1920.

The operating costs per dry ton for both the air lift and the elevators, shown in Table II, are higher than the estimates of Table I, owing to the increased cost of various factors entering therein, but the difference in costs realized by the air-lift plant—practically one-half of the costs of the elevator—proved to be even greater than that expected when the original estimate was made in 1918.

In designing the plant, the compressors were equipped with recording tachometers, recording air gages, meters on the electrical auxiliary equipment for the condensers, and all necessary instruments so that accurate daily records could be kept. All costs of labor required for operation and repair of the plant and compressors were carefully kept and included in the detailed costs shown. More detailed figures covering a summary of the conditions under which the air-lift plant operated during the sixteen-month period are given in Table III, Table IV, and Table V.

The actual dry tonnage handled was determined definitely by subtracting the tons of concentrate from the tons of ore milled. The revolutions of the air compressor were determined from the tachometer and speed-counter readings, and the cubic feet of air and isothermal horsepower, which vary in direct proportion with the speed, were ascertained by the use of proper factors. The number of gallons of pulp handled and the consequent water horsepower depended entirely upon the dilution of the pulp itself, which averaged about 15 per cent solids by weight. This factor of 15 per cent solids by weight was used throughout, and variations above and below this amount, which occur at times, are the principal cause of the variation in efficiency, or quantity of air per gallon of pulp, shown in this table.

In the table of operating costs (Table IV), the charges for steam consumed and auxiliary electrical power were taken from the regular power-house records. The compressors operated condensing and were equipped with a barometric-type condenser plant of the proper size to serve them. They were also connected to the service condensers, serving the large generator engines in the power plant, and, in so far as possible, were served by these condensers, the auxiliary power being proportioned. The operating labor charge covers two hours of the time of one operator on each shift. This operating labor was practically constant, regardless of the tonnage of tailing lifted, and for that reason the cost per ton lifted tended to decrease as the mill tonnage was increased. The items of labor and repair and supplies include lubricating oil, grease, and like necessaries for the air compressors, all repairs necessary for occasional cleaning of the submergence pits, and material and labor used in making slight alterations in piping found by experience to be advantageous for convenient operation.

Before making a careful study of these tables, the design and operation of the air-lift plant should be understood thoroughly, for that will assist greatly in an understanding of the characteristics of the air lift in general, as well as of this particular installation.

The tailing is carried from the mill through a tunnel about 300 ft. long and discharged into a large sump shown in elevation in Fig. 1. The discharge of this tunnel, shown at the left of the drawing, is provided with a fall of about three feet to accommodate a sampler operated by compressed air. From this point the tailing flows through a launder to the submergence pit shown at the right of the elevation drawing. A shaft was first sunk to a depth of 103 ft. 4 in. This shaft was then lined with concrete, and six submergence pits, each 42 in. in diameter, were constructed within this space. This design was adopted because it was thought that the solid material might settle around the bottom of the air-lift discharge columns, causing

TABLE III. SUMMARY OF RESULTS. AIR-LIFT OPERATION, 1919–1920

					Average per Minute												
Period	Average Wet Tons	Average Dry Tons	Discharge Column	Average R.p.m.	Wet Tons	Dry Tons	Cu.Ft. Piston Displacement	Actual Air, Cu.Ft.	Gallons Pulp	Cu.Ft. Actual Air per Gallon	I.Hp. in Steam Cylinders	Auxiliary Hp.	Total Hp.	Water, Hp.	Efficiency to I.Hp. in Steam Cylinders	Efficiency to Total Hp.
1919																
September.........	31,505	4,726	A-B	75	21.9	3.28	1,311.7	1,082	4,766	0.227	131	13.1	144.1	53.0	40.5	36.7
October...........	26,053	3,908	A-B	75	18.1	2.71	1,311.7	1,082	3,942	0.274	131	13.1	144.1	44.0	33.6	30.5
November.........	36,445	5,473	A	86	25.3	3.80	1,504.1	1,240	5,514	0.225	150	15.0	165.0	61.3	40.8	37.2
December..........	29,560	4,434	A	75	20.5	3.08	1,311.7	1,082	4,472	0.242	131	13.1	144.1	49.6	37.9	34.4
1920																
January...........	22,675	3,401	A	67	15.7	2.36	1,171.8	967	3,431	0.282	117	11.7	128.7	38.1	32.5	29.6
February..........	26,827	4,024	A	76.5	18.6	2.79	1,338.0	1,102	4,059	0.272	133	13.3	146.3	45.0	33.8	30.7
March.............	34,725	5,209	A	88	24.1	3.62	1,539.1	1,269	5,254	0.241	153	15.3	168.3	58.4	38.0	34.7
April.............	34,895	3,234	C	97	24.2	3.64	1,696.5	1,400	5,280	0.265	170	17.0	187.0	58.6	34.5	31.3
May...............	35,907	5,386	C	103	24.9	3.74	1,801.5	1,485	5,433	0.273	180	18.0	198.0	60.2	33.4	30.4
June..............	32,982	4,947	C	93	22.9	3.43	1,626.6	1,341	4,990	0.269	162	16.2	178.2	55.4	34.2	31.1
July..............	35,260	5,289	C	95	24.5	3.67	1,661.6	1,370	5,334	0.257	166	16.6	182.6	59.1	35.6	32.3
August............	34,107	5,116	C-A	100	23.7	3.55	1,749.0	1,442	5,160	0.279	175	17.5	192.5	57.3	32.8	29.8
September.........	39,186	5,878	A	102	27.2	4.08	1,784.0	1,470	5,928	0.248	178	17.8	195.8	65.8	37.0	33.6
October...........	34,750	5,213	A	88	24.1	3.62	1,539.1	1,269	5,276	0.240	154	15.4	169.4	58.6	38.0	34.6
November.........	31,985	4,796	A-B	86	22.2	3.33	1,504.1	1,240	4,839	0.257	150	15.0	165.0	53.7	35.8	32.5
December..........	18,700	2,805	B	66	13.0	1.94	1,154.3	952	2,830	0.336	115	11.5	126.5	31.4	27.3	24.8
Total............	14,719,480(*a*)	2,207,922(*a*)	....	....	....	....	......	....	....	.....	.....	....	.....	....	....	....
Average..........	31,723	4,758	....	85.7	22.0	3.30	1,498.9	1,242	4,793	0.2595	150.2	15.0	165.2	53.3	35.5	32.2

(*a*) Based on actual days air lift was in operation.

TABLE IV. OPERATING COST. TAILING AIR-LIFT PLANT

Period	Dry Tons Lifted	Power: Steam	Power: Electricity	Compressor Labor Operating	Plant Repair Labor	Supplies: Compressor	Supplies: Plant	Total	Cost per Ton Lifted
1919									
September	127,123	$589.94	$120.97	$181.00	$5.16	$23.78	$7.92	$928.77	$0.007306
October	81,286	528.44	109.99	119.80	1.53	......	......	759.76	.009347
November	125,887	696.71	104.76	131.27	.....	131.27	30.00	1,094.01	.008690
December	135,680	790.56	167.38	173.63	5.84	30.38	12.60	1,180.39	.008700
1920									
January	105,440	698.43	94.94	171.89	13.63	24.74	......	1,003.63	.00952
February	116,700	805.85	120.89	154.54	85.98	58.74	45.93	1,271.93	.01090
March	158,870	993.97	122.78	184.37	50.00	76.06	53.09	1,480.27	.00932
April	157,030	1,089.20	135.02	168.36	40.00	52.32	50.00	1,534.90	.00977
May	166,970	1,230.91	134.41	169.46	45.00	34.30	39.65	1,653.73	.00990
June	148,420	1,159.19	149.76	159.35	27.93	37.24	3.20	1,536.67	.01035
July	163,960	1,229.63	155.48	181.64	22.84	47.86	8.36	1,645.81	.01004
August	161,670	1,238.38	170.02	162.26	59.61	69.06	27.39	1,726.72	.01068
September	176,340	1,090.22	145.19	167.27	.....	93.37	4.59	1,500.64	.00851
October	161,590	1,150.40	167.84	174.23	7.40	78.19	30.00	1,608.06	.00995
November	142,976	1,072.86	158.58	174.65	66.20	65.59	40.00	1,577.88	.01104
December	77,980	795.73	185.21	167.39	60.00	67.40	30.00	1,305.73	.01674
Total sixteen months	2,207,922	$15,160.42	$2,243.22	$2,641.11	$491.12	$890.30	$382.73	$21,808.90	....
Average per dry ton lifted	......	$0.00687	$0.00102	$0.00120	$0.00022	$0.00040	$0.00017	$0.009878	....

them to choke, and that it would therefore be necessary to provide other individual pits so that any one of them could be discontinued and cleaned independently of others that might be in operation. Individual launders and gates were provided for each pit, so that any one or any combination of pits could be operated independently of the others. This arrangement is shown in the plan on Fig. 1, the arrows indicating the flow of the material to the proper right-hand pit as the gates are set.

During the tests, and also in subsequent operations, it was demonstrated that the air lifts were practically free from the danger of choking. The pits cleared themselves after as much as 32 feet of sand had been allowed to settle above the bottom of the foot piece. It is evident from the experience gained in this installation, that individual submergence-pit construction is unnecessary and that a single submergence pit, large enough to accommodate all of the various sizes of pipe required for flexibility of service, would be much cheaper in first cost and just as satisfactory in operation.

All of the discharge columns empty into a common, concrete discharge box. Each discharge column is provided with a concrete, umbrella-type deflector, which is suspended from timbers fastened to the top of the concrete box by a yoke and wedge. A steel superstructure, as shown in the illustration, carries an overhead crane, which serves the six pits, so that the pipe can be removed from any one of the pits without disturbing any of the others which may be in operation. The handling of the discharge columns by this superstructure has not been as satisfactory as it should be, and in another installation the design would be altered materially.

The air-lift discharge columns are made up of standard wrought-iron pipe, flanged coupled. They have been in operation for sixteen months, but show no appreciable wear, either from abrasion or chemical corrosion. To take care of the varying tonnages, three sizes of discharge-column pipe are installed, as shown in Fig. 2. For each one of these discharge columns there is a corresponding set of efficiency curves, similar to Fig. 3, which shows column "A" only, which have been compiled from tests and which show the economical range of capacity. These curves are based on data taken during the tests made in July and August, 1919. The capacities at that time were accurately measured in a 63,000-gal. displacement tank which was provided for that purpose. The indicated horsepower was taken from both the air and steam cylinders of the compressors. Samples of the pulp handled were taken and the specific gravity and percentage of solids by weight carefully determined. For publication, the curve was plotted on the basis of:

1. Water horsepower referred to isothermal horsepower in the air entering the foot piece.
2. Water horsepower referred to indicated horsepower in the air cylinders.
3. Water horsepower referred to indicated horse-power in the steam cylinder.
4. Water horsepower referred to indicated horsepower in the steam cylinders, plus ten per cent for condenser auxiliaries serving the compressor.

This was done for the convenience of the reader, as there is some confusion of the term "air-lift efficiency." To the practical man, Curve No. 3 is of principal interest, including as it does the over-all efficiency of the compressor. This should be the accepted basis of comparison, but as a matter of fact, Curve No. 1 is more commonly used.

From a theoretical standpoint, Curve No. 1 is of interest because it shows the efficiency of the air lift as a pump, and gives the percentage of energy actually recovered from that supplied, although, unlike other pump efficiencies, there is no way of segregating pipe friction from the static head to be overcome, and no credit is given the pump for this factor. It is also of interest that tests were run with clear water under the same pumping conditions, and it was found that about ten per cent better results, or from two to four unit percentage better efficiency, could be obtained with the clear water than when handling pulp. In the series of eighty tests made to determine efficiencies, a submergence of 67.6 per cent was found to be the most desirable.

Examination of these curves shows that each discharge column has a peak efficiency at some fixed capacity, but the range in either direction at which acceptable efficiency is obtained is sufficient to provide for ordinary fluctuations in the tonnages treated in the mill. It is possible to obtain the same peak efficiencies when using a constant diameter discharge column lifting a somewhat less tonnage of material, but the curve will drop more sharply on either side of the peak whenever the tonnage is increased or decreased than when a tapered discharge column is used. The principal reason that there is a wider range of capacity without much loss in either direction away from the peak efficiency is due to this tapered discharge column. As shown in Fig. 2, the increases in diameter in the discharge columns have been made at convenient joints, but if the diameter of a discharge-column pipe had been uniformly increased from the foot piece to the point of discharge, the efficiency would have been further increased.

TABLE V. COMPILED FROM TABLE III

Year	(a) Duty, Foot Pounds Per 1,000 Lb. Steam, Compressor Only	(a) Duty, Foot Pounds Per 1,000 Lb. Steam, Including Auxiliaries
1919		
Sept.	54,900,000	49,900,000
Oct.	45,500,000	41,300,000
Nov.	55,300,000	50,450,000
Dec.	51,500,000	46,850,000
1920		
Jan.	44,250,000	40,200,000
Feb.	46,050,000	41,900,000
March	51,800,000	47,100,000
April	46,900,000	42,600,000
May	45,550,000	41,400,000
June	46,500,000	42,250,000
July	48,500,000	44,100,000
Aug.	44,500,000	40,450,000
Sept.	50,250,000	45,700,000
Oct.	51,500,000	46,850,000
Nov.	48,700,000	44,250,000
Dec.	37,100,000	33,750,000
Average	48,050,000	43,700,000

(a) Duty computed on basis of 14.6 lb. average water rate for compressor and approximately 10 per cent additional for condenser auxiliaries. Steam conditions 170 lb. gage pressure; no superheat; 4 in. Hg absolute back pressure.

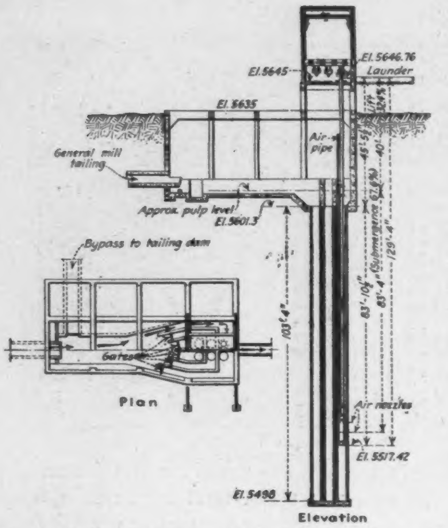


Fig. 1—General arrangement of tailing air-lift plant.

One and sometimes two mill sections are frequently placed in operation, or vice versa, without changing discharge columns or without any readjustment of the air compressor, and the increased or decreased load is taken care of automatically by the air lift without particular attention. This increase or decrease in tonnage is likely to involve as much as 3,000 to 4,000 dry tons of tailing. When lifting the smaller tonnage of tailing, as illustrated by the discharge column "A" shown in Fig. 3, so large an increase or decrease as stated above is somewhat too great to keep the efficiency at the highest point, and should not be practiced on these smaller discharge columns. However, on the larger discharge columns the change in efficiency by such a large increase or decrease in the flow of tailing will not be so great and would be permissible without changing to a larger or smaller discharge column.

The curve shown in Fig. 3 was taken from Table III, discharge column "A," and shows that the range of capacity, at an acceptbale efficiency, is between 3,500 and 4,800 gal. of pulp per minute. Between these points, the highest efficiency to be obtained by this particular column is only two per cent lower than that of the maximum efficiency to be obtained by this discharge column as shown in Curve No. 4. The equivalent tonnage of tailing corresponding to the number of gallons of pulp per minute is from 3,470 to 4,600 dry tons per day. This air lift may be operated within lesser or greater limits, depending upon the range of efficiency desired. When a greater or lesser capacity than that shown to be most economical is desired, a larger or smaller discharge column should be used. It will be noted in Table III that during the sixteen months' period of operation, the discharge columns were changed only a few times.

The Kimball type of foot piece, illustrated at the bottom of Fig. 2, consists of an inner discharge tube surrounded by an annular air chamber and equipped with nozzles leading from the air chambers to the discharge columns. The open bottom in this type of foot piece seems to be the secret of the freedom of the air lifts from choking, as it permits all solid matter to drop out of the air chamber when the column is in operation, and when it is not in operation the sand settles on the outside. This same sand seals the bottom of the air chamber and keeps the air passage open and ready to start the air lift when the air is turned into it. The only appreciable wear that has occurred in the entire plant has been in the foot pieces, two of which have worn badly around the air nozzles, owing, apparently, to the high velocity of the entering air and the resultant sand-blast effect. It is thought that this can be overcome to a large extent by the proper selection and design of material of which these nozzles are made.

The Ingersoll-Rand Co. designed a foot piece and discharge volumn for the purpose of increasing the efficiency of the air lift. This foot piece and discharge column was installed but has not yet been tested exhaustively, for the reason that the present industrial depression has caused a gradual decrease in the tonnage milled, so that the tonnage of tailing was by far too small to permit the foot piece and discharge column to be tested out at its rated capacity.

The Ingersoll-Rand foot piece is shown in Fig. 4 and is of somewhat the same general design as the foot pieces previously described. The special features consist of a long, bell-shaped inlet permitting easy entrance of the

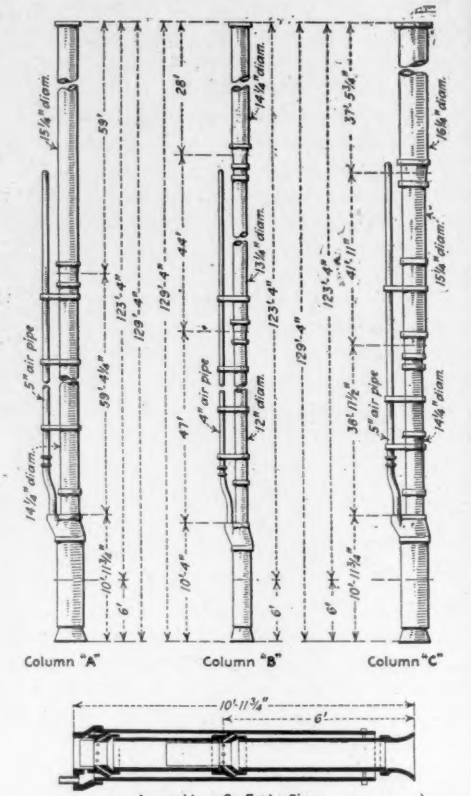


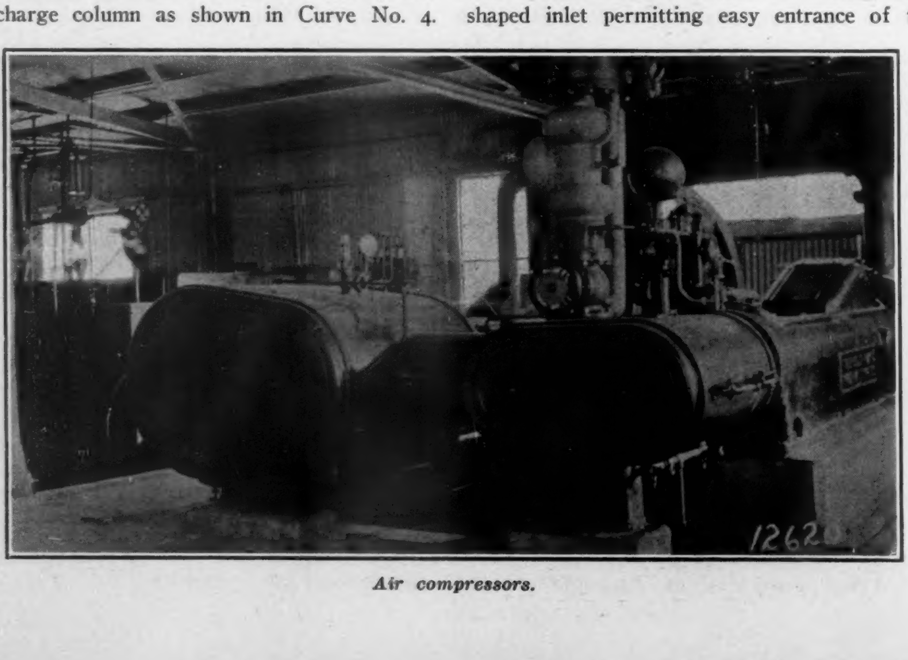
Fig. 2—Arrangement of lift columns.

liquid at the bottom of the foot piece and gradual acceleration up to the point where the air is introduced. In the main body of the foot piece, a slight Venturi effect is used and the air is introduced through numerous small air nozzles located above the neck of the Venturi. The object of this was to prevent sudden acceleration of the column at the point where the air was introduced and the volume consequently increased, and to permit a much more gradual increase in velocity than is obtained by the use of one or two rows of nozzles only.

The increased diameter of the column at this point also assists in eliminating this sudden increase in velocity and the consequent hydraulic shock. Above the foot piece, standard 14-in. outside diameter piping was used for a distance of 43 ft., and from this point to the discharge a special welded pipe was installed, increasing uniformly from 14 to 16 in. outside diameter, this special piping being 76 ft. long. The object of the design of this entire column was to eliminate to the greatest possible degree any sudden changes and consequently hydraulic shock due to the admission of air at any one point in the column and to the sudden change in diameter obtained with ordinary increasers.

As stated above, up to the present time it has not been possible to make accurate tests to determine the increase of efficiency that this design would effect, but it is expected that the power consumption will be cut down from five to ten per cent and the efficiency increased from two to four unit per cent.

The plant supplying compressed air to this air-lift installation is in the main power house, is 530 ft. from the air lift, and consists of two Ingersoll-Rand, Imperial Type XPV-4 steam-driven air compressors having compound steam



Air compressors.

cylinders 13 and 29 in. in diameter and duplex single-stage air cylinders 22 in. in diameter by 20 in. stroke. Either of these air compressors is capable of operating the air lift to very nearly maximum capacity. In selecting these machines, careful consideration was given to economy; this type being chosen because of the low water rate which it showed and the practically flat economy curve down to half speed or somewhat less at which the compressor might be operated a large part of the time. One of the most interesting and valuable features of the entire plant is the method by which these machines automatically maintain the most economical speed to take care of the variations in the tailing tonnage from the mill.

These compressors are usually fitted with oil-pressure governors acting on the high-pressure steam cut-off, and controlled both by the speed of the machines and the air pressure. In ordinary service, as the air pressure decreases,

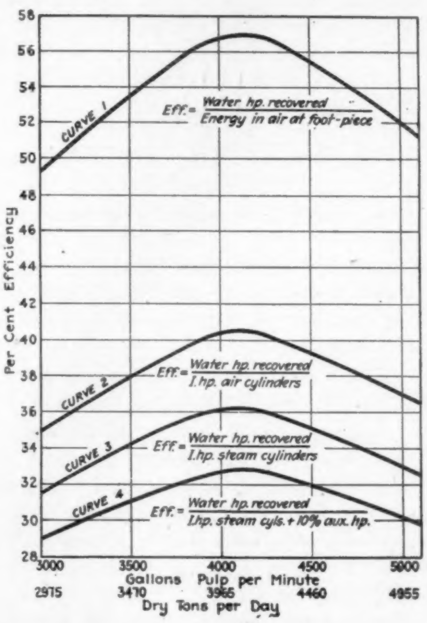
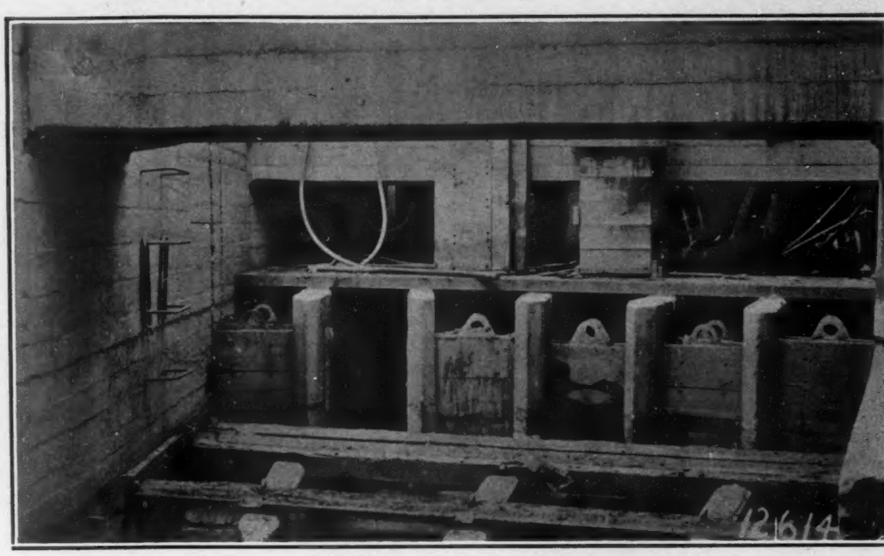


Fig 3—Efficiency curves for column "A."

the governor acts to increase the speed of the machines, and vice versa. In this case exactly the reverse action was required, and the governor was altered so that an increase in pressure would increase the speed of the machine, and a decrease in pressure would cause the machine to slow down. By this action, the pulp level, shown in Fig. 1, is maintained constant within one or two feet, regardless of the fluctuations of the tailing tonnage from the mill.

As the air pressure depends entirely on the hydrostatic pressure, and varies as the pulp level rises or falls in the submergence pit, the method of control operation may be readily understood. As an example, if an additional mill section were placed in operation, the tailing would come to the submergence pit much faster than the air lift had been handling the tailing, and the pulp level would gradually rise. The resultant increase of pressure acts immediately on the air compressor, increasing its speed until a sufficient volume of air is supplied to lift the increased tonnage and until the air pressure and the pulp level again become



Inlet gates.

normal. This feature practically eliminates constant attendance. The mill shift foreman makes an inspection trip every two hours, and the power-plant engineers make occasional inspections of the air compressor. This attendance is all that is necessary for the entire installation.

The automatic governor control eliminates the necessity for any elaborate float system or throttle system in the air lines, which are wide open from the air compressor to the air lift at all times. The entire controlling device is in the power house at the compressors, and the power-house operator can tell at all times very closely the conditions under which the air lift is operating, merely by looking at the pressure gage and tachometers attached to the air compressors.

The operation of this air lift and the economy which it has demonstrated over that of the bucket elevators has considerably exceeded expectations, and it is evident that this device, when properly installed, is one of the cheapest methods of lifting pulp or other solutions, judged from an operating standpoint. The first cost, compared with other methods, will have to be determined for each installation. Difficulties in operation which it was expected might develop have been conspicuous by their absence, and it has not been found necessary to change materially any of the important details of the installation.

In conclusion I should record the fact that during the sixteen months of actual operation it has been demonstrated that the operating cost by the air-lift plant is only 50 per cent of that of the bucket elevators lifting the same material in the mill. This plant has the additional advantage of occupying less floor space and of possessing a greater range of capacity, and therefore greater flexibility, and greater continuity of service. It most thoroughly deserves, to say the least, more consideration in future designing of mill plants than it has been given heretofore.

Acknowledgment is hereby made to E. J. Franklin, consulting mechanical engineer for the Chino Copper Co., who supervised the general design of the air lift and who directed personally a very comprehensive series of eighty tests to determine efficiencies; to H. T. Abrams and H. A. Campbell, of the Ingersoll-Rand Co., whose helpful suggestions have contributed largely to the success of this installation; to

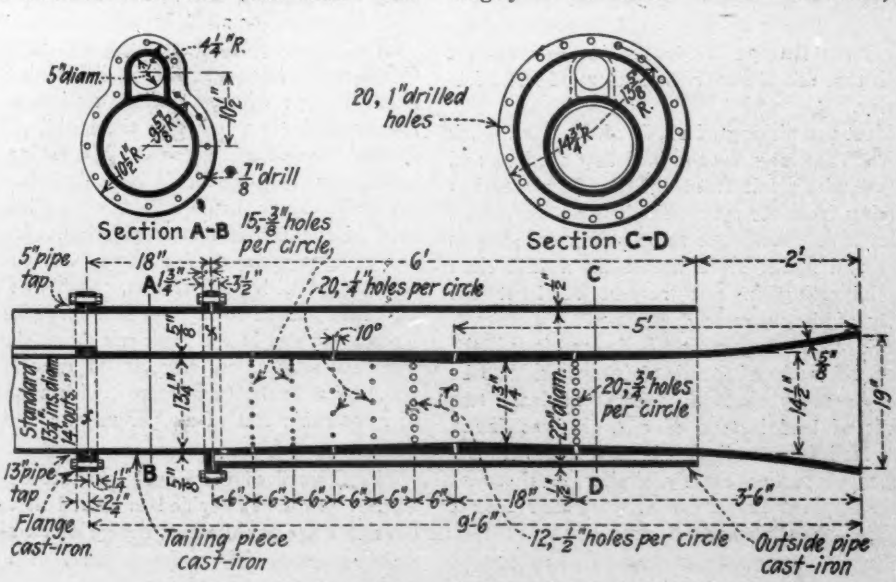
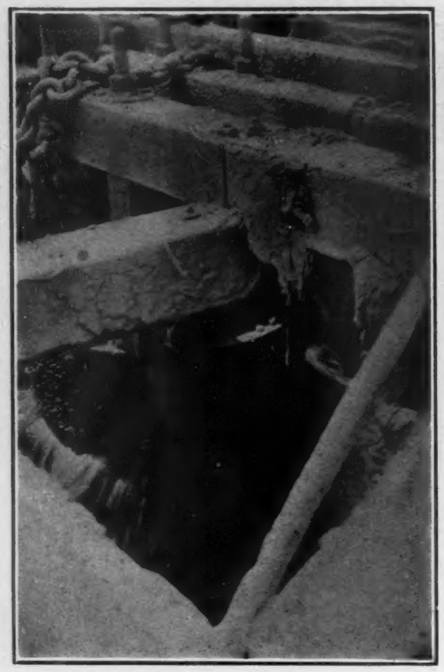


Fig. 4—The Ingersoll-Rand foot piece.



Discharge deflectors.

Henry Merry, formerly chief draftsman for the Chino Copper Co., who collected and compiled the data for this article; and to those many other employees of the Chino Copper Co. whose keen interest and aid have so largely influenced the successful operation of the air lift.

40 ATOMIC WEIGHTS FIXED

THE ATOMIC weights of nearly forty of the ninety or more chemical elements out of which everything in the universe is built have been definitely determined by Harvard chemists in the course of investigations begun thirty-five years ago and extending up to the present time.

The atomic weights of the elements are described as the relative weights in which these elements combine with each other to form the countless substances of which the universe is constructed. These weights have usually been found to be amazingly constant. Silver from all parts of the world and from many different ores has always the same atomic weight. Copper from Europe is identical in this respect with that mined under the bottom of Lake Superior.

Most astonishing of all, Prof. Baxter's work at Harvard long since proved that the iron and nickel which fall from the sky in meteorites coming from the spaces far beyond the earth's orbit have exactly the same atomic weights as iron and nickel from the earth, a fact cited as indicating in one respect at least the unity of the universe.

The most important single result of the Harvard study of atomic weights is said to be the discovery that there exist at least two kinds of lead instead of one. It was found that lead from radium minerals, while it possesses properties exactly similar to those of ordinary lead has a distinctly smaller atomic weight, 206.1, as against 207.2.

The lead from radium minerals is supposed to come from the decomposition of radium. Why its atomic weight is different from that of ordinary lead, whether ordinary lead may not itself prove to be a mixture of lighter lead with a heavier variety, perhaps due to the disintegration of the element thorium, and whether other elements, hitherto supposed to be final and indivisible, may not also prove to be mixtures and thus open up a whole series of new problems as to the composition of matter are questions to which the answers are being eagerly sought all over the world to-day.

Among the atomic weights determined are those of calcium, magnesium, zinc, nickel, iron, meteoric iron and nickel, uranium, Caesium, sodium, potassium, chlorine, nitrogen, silver, sulphur, carbon, lithium, lead, radio-active lead, aluminum, mercury, silicon, boron, lanthanum, arsenic, bromine, cadmium, chromium, iodine, manganese, neodymium, praseodymium and phosphorus.

A COSTLY LESSON IN EXPLOSIVES

It appears that the Oppau catastrophe, the most destructive accidental explosion on record, was from a store of about 4500 tons of a compound of ammonium sulphate and ammonium nitrate known as Ammonsulphatsalpeter. This compound had hitherto been considered absolutely free from any danger of explosion, and for years past, when removing it from warehouses, explosives had been used to break up any large hard blocks which might have formed without any suspicious phenomena having been observed. Ammonium nitrate and ammonium sulphate, say the experts, may form a double salt, $2NH_4NO_3(NH_4)_2SO_4$, which contains 54.8 parts of ammonium nitrate and 45.2 of ammonium sulphate, but this double salt was also considered to be non-explosive. It may be remembered that the destructive power of nitro-glycerine was first brought to the knowledge of the public in a similarly sensational way.

A mechanical messenger, with the speed of Winged Mercury, is to be a feature of the communication system at the new Bank of Italy head office building, San Francisco.

The system installed by the Lamson Company is the largest in any bank on the Pacific Coast, and is known as the "Bell Mouth Power Control" type with 27 stations or independent lines reaching 27 points in the building. The Central Station will be on the Mezzanine, with connections terminating in each department at the bank. More than a mile of tubing has been used in completing this installation, which involves some 500 curves or turns. Each station is equipped with five carriers, capable of moving at the rate of 50 feet per second. Messages from any point in the bank can reach the central desk within five seconds. Power is provided by a Turbo Compressor, with a capacity of 2,000 cubic feet of air per minute.

The Council of the Royal Institute of British Architects has decided to award its annual Gressel Prize for the best design of an airship mooring mast. The prize consists of a gold medal and the sum of £50.

CALIFORNIA CANNERIES EMPLOY COMPRESSED AIR

By C. W. GEIGER

WITH THE production of canned fruit and vegetables valued at $108,096,675.00 during a single year, California's canning industry overtops that of any other state in the Union and her total pack equals, if not exceeds, the packs of all other states combined.

The first of California's cultivated fruits and vegetables came with the padres. When the Mission fathers came to California they converted virgin valleys into gardens where pears, peaches, grapes, olives and other fruits grew luxuriously. In fact, these primitive plantings may be considered the forerunner of the now world-famous fruits of California.

Fruit canning in California began about sixty years ago, but only during the last thirty years has it attained its present greatness. It still promises more wonderful development.

In 1863 the total pack in California was estimated at 7,000 cases, and those engaged in the canning business labored under incessant difficulties. All cans were made by hand, and in the preparation, handling and processing of the fruit automatic machinery was unknown.

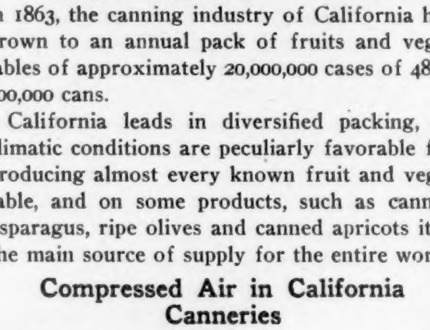
From a pack of 7,000 cases of canned fruits in 1863, the canning industry of California has grown to an annual pack of fruits and vegetables of approximately 20,000,000 cases of 480,000,000 cans.

California leads in diversified packing, as climatic conditions are peculiarly favorable for producing almost every known fruit and vegetable, and on some products, such as canned asparagus, ripe olives and canned apricots it is the main source of supply for the entire world.

Compressed Air in California Canneries

The mechanical equipment of practically every cannery in California includes one or more air compressors, for supplying compressed air which is used very extensively in the canning operations.

There is no single factor in the canning industry which is of more importance than the accurate and uniform control of the temperature in the cookers, exhaust boxes and lye scalders. In this temperature control, compressed air plays a very important part. Following is a detailed description of the temperature control equipment shown in the illustration. It consists of a unit calibrated tube thermostat, metal diaphragm "Sylphon" steam valve and an electric driven air compressor.



Scene in a cannery showing how pneumatic hoists handle certain products.

The temperature regulating devices and the apparatus for this particular purpose has been developed from temperature control devices used in the control of heating systems, but especially designed to meet the requirements of the canning industry.

The apparatus is simple, durable and efficient and is so arranged as to be easily adaptable to cookers, exhausters, scalders, processors and drying apparatus.

The unit calibrated tube thermostat has been especially designed for use in machinery for canning and is of the type known as an inserted thermostat in which the only element affected by the temperature is exposed to the control medium, and the mechanism is outside where it can be easily seen and adjusted when necessary to change temperatures. It does not in any way interfere with the contents of the machine.

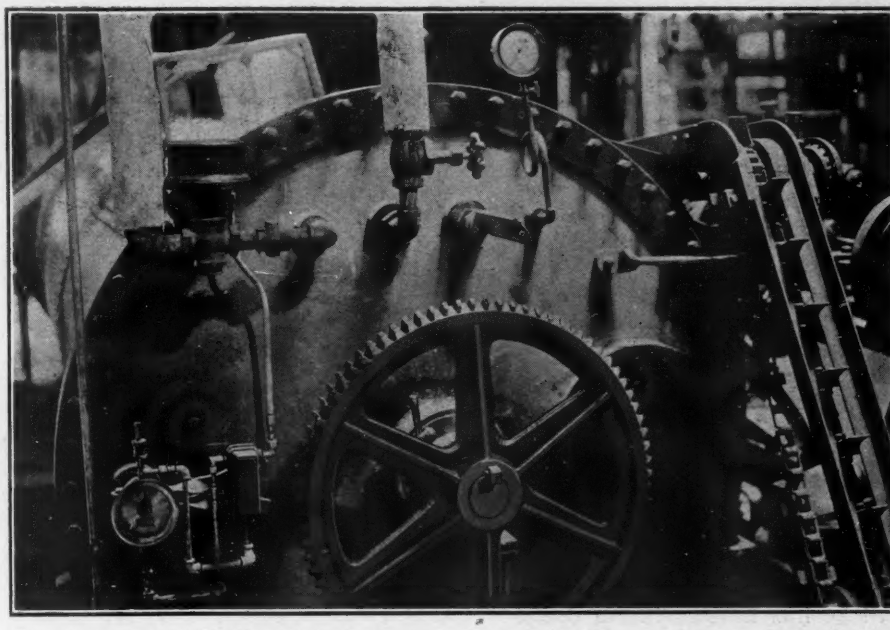
For the assistance and guidance of the operators, the instrument is provided with three plainly read indicating devices, which show at a glance what the instrument is doing and under what conditions it is working. One indicator shows the air pressure supplied to the instrument, another indicator shows the air pressure which the instrument is delivering to the diaphragm valve to be controlled, and the third shows whether the diaphragm valve is open or closed.

The instrument has a wide range of 80 degrees, permitting the temperature of the machine into which it is inserted to be carried at different degrees of temperature to meet the requirements for different products. It is provided with a plain, legible dial and a pointer showing the degree of temperature at which the instrument is operating.

It is entirely of metal, having no rubber diaphragms to open and close. For the canning industry, the valve has been constructed to operate against a steam pressure of 125 pounds per square inch.

The air compressor is designed to furnish air at fifteen pounds pressure which is sufficient to operate the thermostats and valves of the system to which it is attached. It is provided with an automatic electric governor which starts and stops the motor as the pressure falls or rises, thereby providing a constant, even air pressure of fifteen pounds per square inch.

The compressor and air receiving tank may be located in the engine room or any other convenient and desired place as it is connected



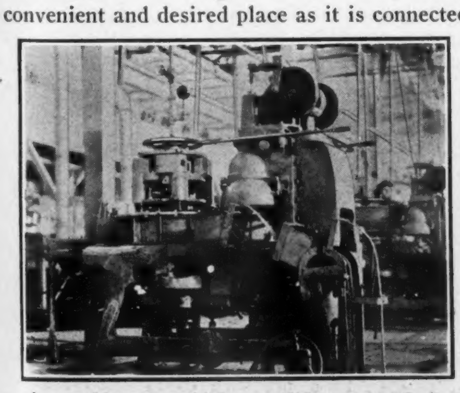
Showing a compressed air temperature control equipment in a cannery. The thermostat is shown at the left with the compressed air pipe connecting the thermostat and the Sylphon valve. This valve controls the steam entering the cooking retort.

to the thermostats and valves by galvanized iron piping which can be run any distance.

This equipment automatically controls the temperature of retorts, cookers, and other machines, thereby taking the variable "human factor" out of the most important operations in the canning industry—it is a safety factor guarding against possible heavy losses, standardizing product at highest quality, saves fuel and insures the dependable operation of every retort, cooker and other machine. It is accomplished by—first the insert thermostat, which is sensitive to variations of temperature inside the cooker, kettle, retort, etc., and, second, a valve in the steam line which opens or closes by compressed air, automatically controlled by the thermostat so that there can be no departure from the desired temperature of the cooker, kettle, retort, blancher, exhaust box or other machinery.

Supposing the thermostat is set at 211 degrees and the temperature should drop to 210 degrees, the thermostat immediately opens the valve and allows steam to enter until the temperature rises to 211 degrees, then it shuts the valve tightly. This operation, repeating perhaps every minute, indicates how much more accurate and economical it is than manual control.

Compressed air performs a very important service in the cooking and sterilization of canned olives, and in the cooking of canned beans.



A machine in which can lids are picked up by suction or light vacuum and applied to cans at a much faster speed than is possible without it.

After the cans of olives have been properly sealed, they are placed in an iron truck. Several trucks loaded with the canned olives, are run into an iron retort, after which the doors are closed tightly, the steam turned on, and the temperature brought to a certain degree and maintained for the proper period, which thoroughly cooks and sterilizes the package and contents.

Much care must be exercised at this particlar stage. An immediate release of the pressure might cause the internal expansion of the contents of the can to burst it or at least to so badly buckle the can as to disfigure its appearance. In order to prevent this, compressed air is turned into the retort before the steam is released, bringing the pressure to about fifteen pounds and held there. The operator then releases the steam pressure, maintaining the air pressure until the packages are sufficiently cooked to prevent any disfigurement of the cans.

Compressed air is used very extensively in operating hoists in many canneries. At the plant of Libby, McNeill & Libby in Sacramento, air hoists supported on an overhead trolley system are used in handling boxes of pumpkins to and from the cooking retorts.

At this plant there is a special compressor room and pump room built in connection with the boiler house. In the compressor room are two Ingersoll-Rand air compressors, each driven by a fifteen horse power motor, with resistance starter. An air lift pumps water from a 220 foot well into a 2500 gallon reservoir. In the compressor room there is also installed a vacuum pump which is driven by a five horse power electric motor. This vacuum pump is used in connection with the can sealing machines, the vacuum being used in picking up can tops and placing them on the top of the cans filled with fruit. There is also installed in this cannery a vacuum tank of 1200 gallons capacity for reduction purposes, in connection with which there is a Grange vacuum pump.

The type of plows used in America is generally suitable for use in South Africa. The two-furrow walking moldboard plow is the most widely used. Disk plows are used to some extent. The principal feature that the farmer is looking for is a strong and rigid frame; light draft is an important consideration; above all, a plow that can be used in dry, baked soil, in new and rough lands, with unskillful native labor and oxen, is required.

THE USE OF EXPLOSIVES IN STEEL WORKS

*By R. T. SLEE**

IN PRESENTING the following short paper the writer hopes to illustrate some uses of explosives in industrial work under conditions different to those prevailing on mining fields. This paper is based on experience gained at the Newcastle steel works of the Broken Hill Proprietary Company, Limited.

The management had decided that as soon as No. 2 blast furnace—which is of an improved design—was ready to be put into commission, No. 1 blast furnace was to be dismantled and reconstructed to a similar design to No. 2 furnace. This reconstruction entailed the removal of the brick lining of the furnace shaft, and also the removal and disposal of the "salamander" and hearth-lining.

For the information of members who may possibly be unacquainted with the term "salamander," it might be explained that this term is used by iron metallurgists to denote the mass of iron and slag formed at the bottom of the furnace while in commission.

The method of disposal depends upon the size and nature of the salamander, and in the case under review it was decided to bury it below the hearth of the furnace to be reconstructed. A passage-way was made in the concrete walls of the cast house, and the sand-filling of the cast house removed sufficiently to allow of the concrete foundations of the furnace being reached. This passage-way was extended until the hearth was encountered. The next operation was the removal of the hearth-lining below the salamander. The removal of the concrete was not difficult; holes were drilled by the use of "jackhamers," charged with gelignite in the usual way, and fired by ordinary fuse and detonators.

At first some difficulty was experienced in inducing the operators to take the necessary precautions to prevent danger from flying fragments, but this difficulty which was due to inexperience on the part of the men was soon overcome.

On reaching the hearth it was found to be still very warm—in fact, so warm that it was necessary to work the men in spells while in its vicinity.

In order to salvage as many as possible of the two bottom rows of hearth blocks, which appeared to be in good condition, the next operation was to remove the concrete foundation below them; the excavation thus made would also serve as a receptacle for the salamander providing the quantity deposited was not too large.

The same drills were used for boring purposes, but the size of the bits was increased; every hole as drilled had a water hose placed in it in order to cool its walls and to prevent a premature explosion when charging. When ready to fire, each hose was removed and the charge pushed home; the charge was wrapped in a clay envelope as an additional precaution. The use of large-size bits was necessary in order that the clay envelope containing the charge could be inserted with ease.

Many hearth blocks were salvaged by the use of crowbars and an occasional "pop."

As the excavation progressed under the salamander, props were used to prevent it from falling; all the brickwork up to the iron was removed, and also for the space of about 9 in. outside its circumference.

While the excavation was proceeding, the work of dropping the salamander was also put in hand, and this work called for the drilling of holes around the circumference; in all, 15 holes, each about 4 ft. deep, were drilled; these holes were chambered to receive larger charges of explosive. Before charging these holes, a protecting fence of railway sleepers enclosing the space between the top of the hearth jackets and the tuyere jackets, was lashed into position. Each hole was then charged with eighteen plugs of gelignite, and electric-detonators were utilized. For the first two attempts the detonators were connected in series and a rack-bar exploder used. On the first trial one hole only exploded; on the second, only three holes exploded.

In view of these failures, the contractor consented to try another method. The sand tamping was blown out by the use of compressed air, and the detonators removed; fresh detonators and primers were inserted, and the detonators were then connected to the leading wires in parallel. Instead of the exploder being used, current was obtained from the power circuit. By using this method all the holes exploded, but owing to the two previous miss-fires the salamander dropped about 2 ft. only, and then hung up. It was again propped up, and the debris removed. When this work was completed it was found that the salamander was free all round its circumference. A cement bed was prepared for its reception—the supporting props fired, and the mass dropped; all timber was then removed and the salamander concreted in position, forming a foundation for the new hearth-lining.

Another case in which explosives were used was in removing a parapet in order to extend the cast house, and for this purpose it was necessary to remove about 30 ft. in length of concrete, 2 ft. high and 2 ft. thick.

Instead of using hammers and gads, it was decided to blow the parapet off, taking care of course that the wall was not injured by the charges. This work was carried out in the following manner: The grade line was marked on the parapet, and holes drilled about 3 in. apart; the first hole pierced the parapet completely, the next was about 16 in. deep, and the drilling performed in that manner till the whole length of 30 ft. was covered. Light charges of half-plugs of gelignite were placed in solid holes about 2 ft. apart, and fired. The line of holes was the line of fracture, and no damage was done to the wall beneath.

On another occasion the metallurgical staff desired to examine the interior of three forging ingots, which were the first ingots cast in the steel foundry using a cast-iron mould. It was desired to split the ingots longitudinally, and it was thought that explosives might be used to bring about this result.

The first ingot was drilled with eleven 1¼-in. holes, placed 12 in. apart, and 18-in. deep. A trial showed that charges fired for the purpose of chambering had very little effect, the chambered holes only taking from one to two plugs more than the untreated holes in order to give the same depth of charge. Ten holes were charged, the remaining hole being rejected on account of it having ended in slag. The ten holes took 65 plugs; the electric detonators were inserted, and each hole tamped to the collar with clay; the detonators were connected to the firing-wires in parallel.

The whole ingot was then covered with sandbags in order to prevent danger from flying fragments. The firing-wires were connected to a two-pole switch connected with the power circuit; by closing the switch the holes were all fired simultaneously. The result was a thin crack the whole length of the ingot, but apparently only about 6 in. deep as a close examination of the butt-end did not reveal a greater depth.

The holes were again charged, using 85 plugs, and fired as before. This time the ingot was split completely in halves; the two pieces were thrown about 50 ft. from the original site as a result of the explosion.

The second ingot was drilled in a similar manner, excepting that about six holes were drilled from the opposite side and arranged to pass between the holes on the other side. The same procedure was followed as in the first case, 85 plugs being used; a crack similar to the one in the first ingot was the result. Thirteen holes were then recharged, using 65 plugs, and refired. The ingot was completely split, and the top half thrown for a distance of about 6 ft.

In the third ingot the holes were placed 9 in. apart—27 holes in all, drilled from both sides, and charged with 120 plugs; they were then fired as before. The first explosion completely split the ingot, and also broke the two halves circumferentially; one piece was thrown 6 ft. away, and the other about 18 ft. away.

A feature of the splitting of the third ingot was the fact that, as a result of the explosion, a cast the length and shape of the ingot was made in the ground, about 4 ft. deep at one end and tapering to 6 in. at the other end. The depression made by the splitting of the first two ingots was hardly noticeable.

Explosives were also successfully used at Newcastle for loosening the accretions formed on the bottoms of the open-hearth steel furnaces after a campaign.

In any criticism of the foregoing, it should be borne in mind that the explosives were used under conditions very dissimilar to those obtaining in either mining or quarrying operations.

*Paper read before the Broken Hill Branch, Aus. I. M. M.

BUBBLES IN GLASS

Bubbles which are detected in glass in the process of manufacture must of course be eliminated, and the only way would seem to be to stir or otherwise manipulate the materials until they are brought to the surface. A German firm, however, has applied for a British patent for subjecting the glass while in a soft state to a pressure of at least 200 atmospheres so that the imprisoned gases will be absorbed.

Methods of Handling Very High Pressures

Also Recent Interesting Experimental Results Obtained with Various Materials Under Pressures up to 500,000 Pounds per Square Inch

By P. W. BRIDGMAN

IN THIS article the author explains the methods of packing pistons and joints in order to obtain pressures up to 500,000 pounds per square inch and also recounts further experiments with such pressures on various materials.

A previous article "Experiments on the Effects of Extremely High Pressures" in the September issue described changes in the physical properties of materials under these high pressures and as the result of a number of requests for further information, this article covering many more details of this interesting subject is published.

The author has also extended the application of these experiments into the field of geology showing the effects of pressure upon minerals in order to determine how these substances behave under similar pressures in the interior of the earth.—The Editors.

IN THE September number of the COMPRESSED AIR MAGAZINE I had the privilege of describing a number of the results of my experiments at Harvard University with extremely high pressures. These pressures were of the order of 300,000 lb. per sq. in., or ten times the firing pressure of a large gun. One absolute essential in handling such pressures is a suitable method of packing the joints.

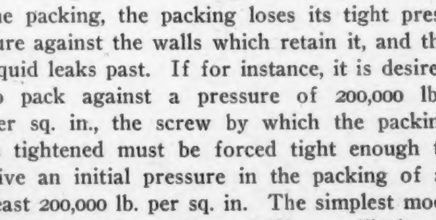
Since this question has aroused some inquiries, and since the principle of the packing is applicable to any pressure, I shall describe the packing in principle and some of the details of its application. I shall also describe some results of engineering interest obtained from the high pressure experiments which were only briefly alluded to in the former article.

The principle of the packing will be obvious from a study of Figs. 1, 2, and 3, which illustrate three stages in the evolution of the packing. In Fig. 1 is shown the ordinary method of packing a joint applied to an air pipe connected to a large vessel. Such a packing is familiar to any one who has pumped an automobile tire. The packing material is squeezed between two opposing members with sufficient force to prevent the air or water, or whatever is carried by the pipe from leaking. The weakness of this packing is at once evident. The packing material squeezes out between the opposing members if screwed up too tightly, so that the joint has to be continually retightened, until eventually all the packing material escapes. The pressures that this packing can handle are moderate; the limit is set by the pressure that blows out the packing.

A modification of this arrangement, by putting a retaining rim around the outer edge of the packing as shown in Fig. 2 prevents the packing from squeezing sidewise, and greatly increases the pressure that it is possible to pack against, because the packing itself may be subjected to a much greater pressure without lateral escape. It is still better if the opposing members are brought into contact by a direct straight push instead of by the rotary motion as in the figure, which has danger of abrading the surface of the packing by the twisting motion.

This simple principle of enclosing the packing on all sides is easy enough when pointed out, but the possibilities of it in scientific work were first realized by the French physicist Amagat, who by the consistent use of it was able to extend by a range of six fold the pressures which were accessible to scientific measurement. The principle is of course of familiar application in industry by this time.

There is an essential limitation to the pressures that can be maintained by a packing like that of Fig. 2. If at any time the pressure in the liquid rises as high as the pressure in the packing, the packing loses its tight pressure against the walls which retain it, and the liquid leaks past. If for instance, it is desired to pack against a pressure of 200,000 lbs. per sq. in., the screw by which the packing is tightened must be forced tight enough to give an initial pressure in the packing of at least 200,000 lb. per sq. in. The simplest modification of the packing of Fig. 2 will change all this. Let us put the packing on the back side instead of the front side of the washer at the end of the pipe, as in Fig. 3. We now have a packing that cannot be made to leak by any



A plug made of solid steel rod which was pinched off at point A by soft rubber packing under too high pressure.

pressure that the walls of the containing vessel themselves will stand. The application of a little high school mechanics will show the principle underlying the operation.

What is it that prevents the pipe from blowing out of the hole? Obviously the pressure exerted by the packing on the ring AB. And what is it that tries to blow the pipe out of the hole? Obviously the pressure exerted by the liquid or gas on the end of the pipe CD. Now since the pipe neither blows in nor blows out, it is obvious that the total force trying to blow it out is equal to the total force holding it in, or in other words, the total pressure exerted by the liquid over the area CD is equal to the total force exerted by the packing over the area AB. But the area AB is less than the area CD. Hence the pressure in pounds per square inch in the packing is greater than the pressure in pounds per square inch in the liquid. The ratio by which the pressure in the packing is greater than the pressure in the liquid is the same as the ratio by which CD is greater than AB.

For example, if the diameter of the pipe is half the diameter of the hole, the area of AB is ¾ of the area of CD, and the pressure in the packing is 33% greater than the pressure in the liquid. This excess pressure in the packing is maintained automatically no matter what the pressure in the liquid. If the pressure in the liquid is 1500 pounds per square inch, the excess pressure in the packing is 500 pounds, and if the pressure in the liquid is 150,000 pounds, the excess pressure in the packing is 50,000 pounds. Hence the liquid can never leak no matter how high the pressure, and the only limitation on the pressures that can be carried is imposed by the strength of the containing vessel.

The only problem that now remains is the problem of preventing the packing itself from leaking. It is comparatively easy to do this by making the metal washers an accurate fit for the containing vessel, although there are complications at extremely high pressures. It is somewhat paradoxical that if the lower washer is not a tight enough fit, the packing will leak into the containing vessel, instead of out, driven by its excess pressure against the pressure in the liquid. It is also somewhat paradoxical that under excessive pressures lead will leak through a smaller hole than rubber. The reason is that rubber becomes rigid, or more properly freezes under pressure, just as a rubber ball loses its elasticity when plunged into liquid air, but the lead is not greatly changed in its properties by the pressure.

The fundamental principle of this packing is that of the unsupported area, in virtue of which the pressure in the packing is always

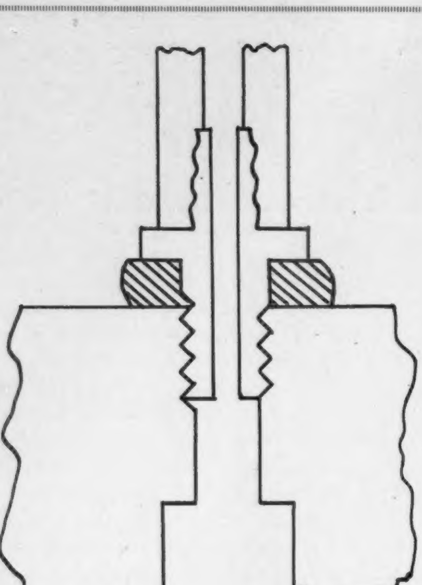


Fig. 1 shows the ordinary method of packing a joint connecting an air pipe to a large vessel.

a fixed percentage higher than the pressure in the liquid. In the case illustrated in Fig. 3 the unsupported area is that of the pipe which projects beyond the restraining plug. In Fig. 4 another method of applying this packing idea is shown, this time to the packing for the end of a piston. Here the unsupported area is that of the end of the stem A. With this method of packing the piston, I have reached pressures in liquids up to nearly 500,000 lb. per sq. in. There is furthermore, absolute freedom from leak, so that except for the wearing of the piston the piston returns exactly to its original position after making a stroke. This permits numerous interesting applications in the way of making physical measurements at high pressures.

As illustrating the vagaries of the patent business it is interesting that I failed to get a fundamental patent on this idea because the plunger of a sausage machine had once shown

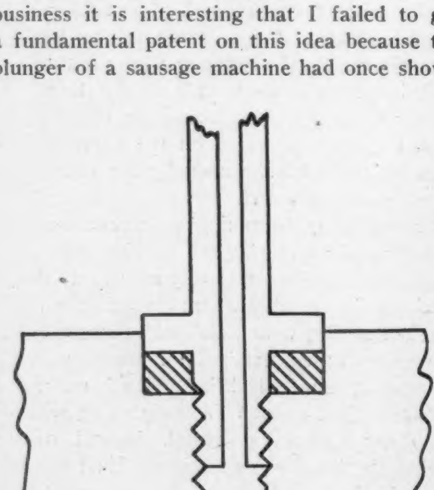


Fig. 2 shows a retaining rim around the outer edge of the packing which prevents the packing from squeezing sideways. This is a modification of the illustration shown in Fig. 1.

a packing of this character, quite by accident, the peculiar design being for another purpose.

The principle of the unsupported area is capable of the most varied application. Anything may be used as a packing material that is sufficiently soft and flexible. The pressures are so tremendous that even soft steel flows into cracks left unguarded, and in some of my packing designs soft steel rings take the place of soft rubber and function with entire success.

Turning now from the question of the packing, I have observed a number of cases of rupture in dealing with these high pressures which are different from the sorts of rupture usually met with, and which are most instructive. It is strange that apparently the engineer has never determined precisely what it is that makes a material break. He can predict that a rod of steel will break if it is pulled too hard or twisted too much, but quite often he cannot tell in more complicated cases just when a substance will break, or in other words, the conditions of rupture are known only for certain special simple cases. The discovery of unusual kinds of rupture is valuable in giving an idea of what may be the conditions of rupture in the general case.

One of the most surprising of these unusual cases may occur to the pipe of Fig. 3. If the pressure in the liquid rises too high, or even if the man with the monkey wrench who tightens the nut is too strong, the soft packing material will be squeezed bodily into the metal of the pipe, which will be pinched off and escape by blowing out through the screw plug. If the pressure at which this occurs is high, the ejection is with great violence, and is one of the chief sources of danger in these experiments with extremely high pressures. I have had plugs blown through eight or ten inches of wood in this way. Such a plug is seen in the first illustration. At the point A the solid steel rod was pinched off by the soft rubber packing. Fortunately the effect does not take place until the pressure in the packing has risen to something about as high as the tensile strength of the steel. Thus a mild steel pipe with a tensile strength of 50,000 lbs. per sq. in. will not fail in this way if the packing is properly designed until the pressure in the liquid has risen to about 50,000 pounds.

The significant thing in this "pinching-off" effect from the point of view of the theory of rupture is that there is no stress pulling apart the fibers that separate. The reason is that the end of the pipe is unsupported, so that there is no force along the length of the pipe. Rupture occurs because the increase of length of the longitudinal fibers of the pipe has become too great. It is exactly like squeezing off a string of putty in the hand. This single example is sufficient to show that it cannot be the force tending to rupture the fibers that is responsible for the break down of material. What then is responsible? Is it perhaps the elongation of the fibers? No, it is not this, as we may show by another example, picked from the numerous kinds of rupture that occur under high pressures. If

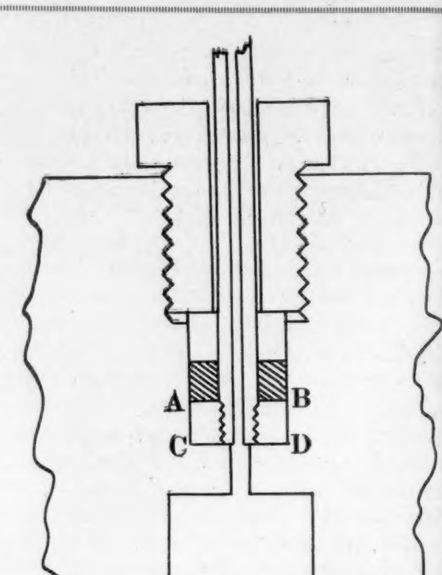


Fig. 3 shows the packing on the back side of of the washer. It will stand any pressure that the walls of the containing vessel themselves will stand.

we make a hard rubber ring with a steel core an exact fit for it, and put the ring with its core into a vessel with liquid, and subject the liquid to a great pressure, we find that the rubber ring is cracked exactly as it would be if it were stretched too much.

Now here is a paradox in more than one respect, for not only is the rubber ring prevented from shrinking by the steel core, so that rupture takes place across fibers in which there is no change of length (or at most a very small decrease of length), but the force in the fibers which rupture is actually a compression instead of a tension, so that here rupture takes place against the direction of the force. What is then the true answer? It has not yet been worked out, and no one can as yet say exactly what it is that makes a piece of steel break, but curious examples such as these at least show that previous ideas have

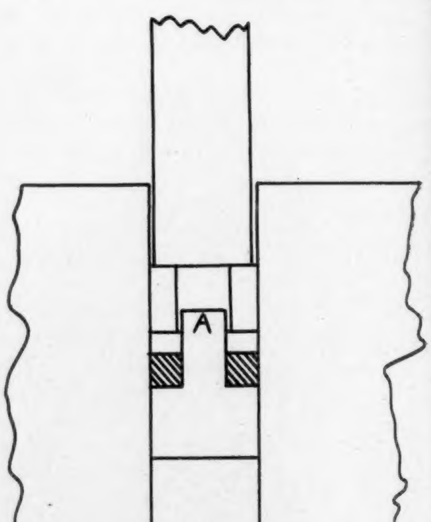


Fig 4—With this method of packing the piston pressures in liquids up to nearly 500,000 pounds per square inch have been obtained.

been wrong and ought to be of much value in suggesting what the correct answer is.

There are other paradoxical effects to be found in the way in which materials rupture under high pressures. Suppose for example that a thick hollow steel cylinder is exposed to pressure over the outside surface in such a way as to tend to collapse it. If the tube is not too thick, it will collapse when the pressure becomes too high by folding in on itself in one or more folds, as a boiler tube sometimes fails. But if the tube has more than a critical thickness, it cannot fail in this way by folding, but must yield differently.

In fact it flows toward the center, so that if the pressure is pushed high enough, we finally squeeze the internal hole out of existence, and have left a cylinder to all appearances that is solid. This will take place at about the same pressure, no matter how thick the cylinder is, which again is paradoxical. If the cylinder is made of soft steel, the hole will be squeezed out of a cylinder with even infinitely thick walls by a pressure of about 250,000 lb. per sq. in. Suppose now that instead of trying to collapse a steel tube, we try the same experiment with one of glass. One would be tempted to say that of course the glass tube could not stand as much pressure as the steel one. This is true of a thin cylinder, for a thin glass tube will break into a thousand fragments at a much lower pressure than a steel tube would support.

But if the tube is thicker, there is a complete reversal of behavior, and a thick tube of glass will support a very much greater pressure on the outside than will one of steel.

I have subjected hollow cylinders of glass to pressures of 350,000 lb. per sq. in. without producing any appreciable effect. Yet if a piece of glass is subjected to an ordinary crushing test in a testing machine, it will break at not more than 15,000 or 20,000 lb. per sq. in. The essential difference between steel and glass seems to be that the steel is composed of microscopic crystals which can flow under pressure, whereas there are no crystals to flow in the glass, which therefore has no way of yielding, and therefore cannot help but support the pressure. One can see of how much interest these matters are for the geologist, who wants to know whether there are open cavities in the interior of the earth.

I have made similar experiments on various minerals in order to find how these substances may behave in the interior of the earth. Hollow crystals of materials such as quartz will stand a much greater stress without collapse when this stress is a pressure such as that exerted in the interior of the earth than under the sorts of stress exerted in a testing machine. The figures obtained by the ordinary tests for the strength of the minerals of which the surface of the earth is composed are much too low, and false conclusions are drawn. When a hollow cylinder, such as quartz, does break under very heavy pressure on the outside, the break is of an unusual character. The inside surface disintegrates and flies off into fragments as fine as dust.

These fragments are projected from the interior surface with almost explosive violence, so that if a rod of metal is placed inside the cavity, its surface will be frosted by minute slivers of rock that have been shot into it like bullets. The disintegration of the rock continues until the hole is so tightly packed with debris as to exert sufficient pressure on the interior walls to counterbalance the effect of the external pressure.

Now it is another curious fact that it is never possible to pack the debris so closely that it has the density of the rock from which it came. I have made experiments on rocks up to pressures of 500,000 lb. per sq. in., and have never been able to force the pieces back into their original volume.

This means that minute fissures persist between the fragments of comminuted rock at very great depths, and that it is possible that water or gas may circulate between the fragments and produce important geological effects.

NOVEL APPLICATION OF A CALYX DRILL

By H. WOOD

THE FOLLOWING account of a Davis Calyx core drill being used for cleaning a vertical pipe line may prove of more or less general application.

In the "Minas de Reunion," Sevilla, Spain, the main pipe line of the turbine pumps got so silted with scale that the pumps had to be closed down and the unwatering of the mine carried on with the auxiliary set. The incrustation reduced the diameter to approximately 3½ inches and the engineers at one time thought they would have to abandon the line altogether, as the cost of taking it out, cleaning and replacing would have been excessive. However before doing this it was decided by the engineers of the mine to try a Davis Calyx drill and with what results the following figures will show.

The total length of the pipe which is cast iron is 1,100 feet and the original inside diameter was as follows: 360 feet, 13 in.; 360 feet, 12 9/16 in.; and 380 feet, 12 3/16 in. The flanges are faced with a nipple and recess so that the joints are quite true. Since the pipe was installed owing to a subsidence in the mine the shaft moved somewhat and in the total length of the line there is divergence from the vertical.

In the line there are five expansion joints and from all accounts the cleaning out of these is the most difficult operation.

For the work a special bit was made and the incrustation cut out in one operation but at 500 feet it was found that the work was too hard on the machine and it is now being done in two cuts. A 4½ inch Davis cutter was run down from the 500 foot level to the bottom in one operation that is to say without removing the rods, opening the hole to about six inches and the special cutter was then put through, cleaning the hole out to size. When using the Davis cutter it was necessary to bring the water and silt up to the top, the water being fed through the drill rods in the usual way. When using the special cutter the water was fed outside the rods the silt being run through the center hole and cleaned from the bottom. At the time of writing 700 feet has been cleaned to a diameter of 11½ inches which will in the future be the standard diameter.

The best results have been obtained running the drill at top speed and an advance of eight feet an hour has been obtained.

As will be imagined the machine is erected in a somewhat restricted space right over the main winding shaft, but the greatest drawback is the limited head room which only allows of a ten foot rod being taken out at a time.

The machine used on the job is a standard Davis Calyx drill type "F-1" operated by air and after this work is finished will be used for prospecting for coal.

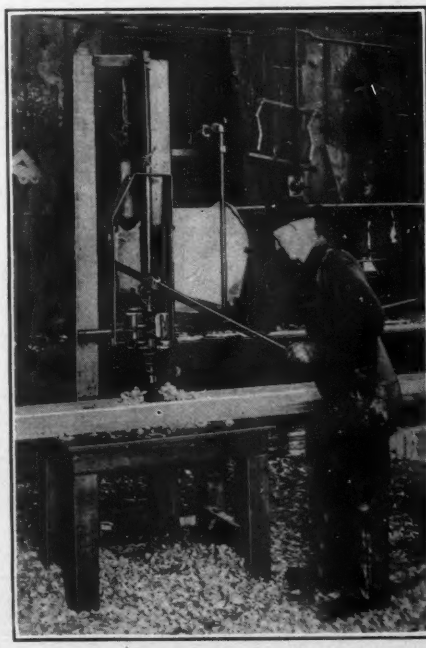
The information for this description was furnished by Mr. Gomez Torga, technical director, and Mr. Juvenal, chief engineer of the Minas de la Reunion, who have been responsible for the successful operation of the device.

MINE TIMBERS DRILLED ON HOME-MADE PRESS

THE USE OF a portable air drill rigged up to form a small drill press, saved a large Montana mine considerable time and labor.

New construction work involved the drilling of about 1,000—4-in. x 9-in. guides for a shaft, each guide having ten holes. The chief mechanic and carpenter boss rigged up a Little David air drill as shown in the illustration, forming a simple but convenient drill press. On this outfit the required holes were drilled at an enormous saving.

The ten holes were drilled in each guide



An air drill rigged up as shown saved much time and labor in drilling mine timbers.

with a Jennings counter-sunk bit, the ⅞-in. portion going through 4-in. of wood and the 2½-in. follower boring 1½-in. Oregon fir was used generally, although oak timbers were drilled with almost equal ease.

This home made drill press could be used around a great many small mines, on similar jobs, the entire outfit being very inexpensive,

Compressed Air Solves Colliery Problem

FIGURATIVELY speaking, any art must walk before it is able to run, and this applies with equal force to the expansion of the service of compressed air. What has been done successfully constitutes a pretty sure footing for a longer and more confident stride. This is impressively exemplified in the increasing employment of compressed air as a medium for the conveyance of materials of differing densities.

As is fairly well known, installations of one sort or another have been working satisfactorily at ports both in the United States and abroad by which grain and other bulk cargoes have been transferred from ship to shore, and vice versa, by means of compressed air. In view of this, certain German mine owners decided to apply the same system, if practicable, to the handling of nut coal, and an equipment was ordered for a plant at Welheim. The undertaking was delegated to an engineering firm at Braunschweig and the agreement called for the designing and placing of apparatus capable of transporting hourly anywhere from 50 to 60 tons of the coal in question over a distance of 325 feet. And for this purpose the contractors provided one electrically-driven, stationary, double-acting air compressor, a tube conveyor, a separator, and a discharge or feeding lay-out.

The object of the installation was to deliver coal from the mine mouth to the steam power plant and, of course, to minimize the employment of labor while speeding up the movement of the fuel. The system has answered admirably, and has been in service now for two years without suffering any serious interruptions by reason of mechanical failure. Indeed, it is reported that the plant has more than paid for itself through the economies resulting from the avoidance of much manual handling.

Previously, the mine's boilers were coaled by means of tilting cars which were loaded at the washery and carried by an electric hoist to overhead bunkers whence the fuel could be deposited on the fireroom floor. By the new arrangement the conveying of the coal is entirely automatic, and the substitution has got rid of a troublesome human equation. In the past, especially during rigorous winter weather, the workers have been frequently disinclined to deliver regularly and in ample quantity the coal needed in the boiler rooms, and difficulty was often experienced in maintaining the much desired head of steam for many functional purposes.

In a general way, the method of operation is as follows: From the compressor, air is delivered into a reservoir, and from the latter, as a source of uniform supply, the impulse medium is led by piping to a point at the admission end of the fuel conduit or conveyor. This conveyor spans the distance between the coal tipple at the mine and the boiler house, and is linked directly with elevated bins from which the nut coal can drop by gravity into the transporting system. That is to say, as the coal falls from the hoppers into the conveyor it is caught by a strong current of air which sweeps it onward and upward. After a journey of 300 feet or more, the fuel reaches the separator—the coal descending and the air escaping into the atmosphere.

One might expect that the air drive would tend to break up the coal, through impact, when it arrives at the crest of the climb, but the separation is effected without this violent action. That is to say, the cross-section of the conduit is increased suddenly at the exit, and this facilitates the expansion of the air, checks the forward urge of the fuel, and permits it to drop right into an underlying bunker having a capacity of about three tons. From this intermediate chamber the material is then diverted to a series of bins. The pneumatic system has done its work so well that it is not unlikely that air will later be employed to blow the coal directly into individual bunkers in front of each boiler. The quantity of coal entering the conveyor can be regulated to suit requirements, inasmuch as the feed is controlled by an electrically-driven bucket-wheel.

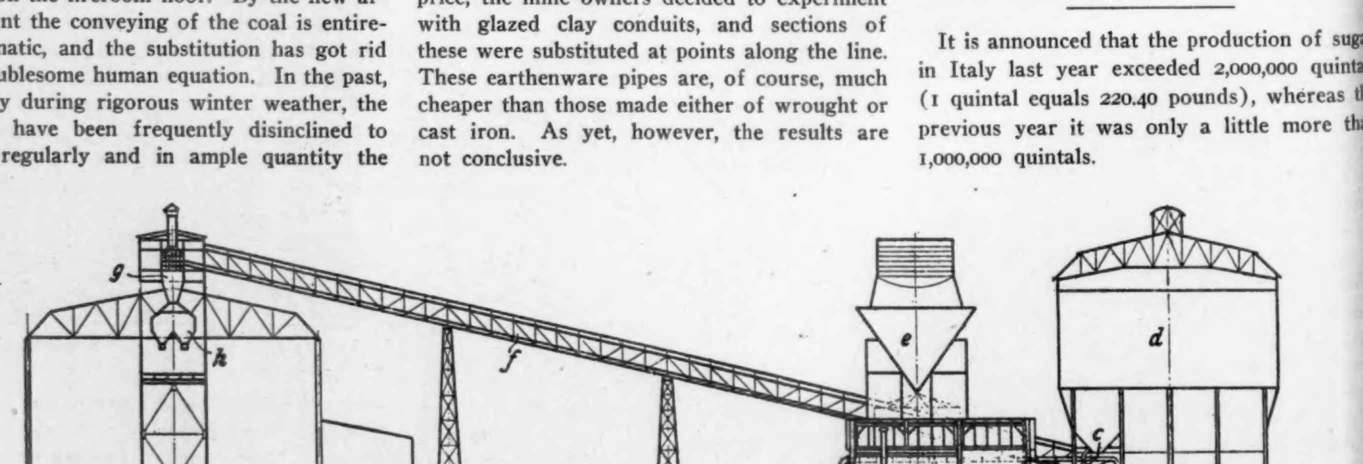
The installation has brought to light one weakness, which was due to the unexpected and rather rapid erosion of the wrought iron tube conveyor. Because of the prevailing scarcity of good cast-iron piping, and its high price, the mine owners decided to experiment with glazed clay conduits, and sections of these were substituted at points along the line. These earthenware pipes are, of course, much cheaper than those made either of wrought or cast iron. As yet, however, the results are not conclusive.

The departure represented by the Welheim plant suggest far-reaching possibilities; and the performances up to date seem to warrant the assumption that pneumatic conveyors of this general character can be readily adapted to meet special local conditions, such, for instance, as leading the mains over railroad tracks or extending them for long distances overland irrespective of the character of the terrain. It is recognized that for short, straight runs of moderate ascent, a belt conveyor will generally serve the purpose, but for greater spans the pneumatic transporter seems preferable. This superiority is accentuated where compressed air is employed in a conveyor that is expected to trace a devious course and to rise and fall abrutly throughout its length.

Hitherto, pneumatic conveyors have handled grain, oil seed, fresh and kiln-dried malt, etc. and in the recent past the method has been adapted to the needs of blast furnaces, smelting plants, chemical factories, cement and lime industries, potash mines, and central stations. Finally, by reason of their experience in moving nut coal and certain tests made by them, the company at Welheim is about to erect an equipment for the pneumatic transportation of accumulated hills of culm. Bearing in mind the tremendous culm banks that dot some of our coal fields, this undertaking should be of suggestive value to us.

It is gradually dawning upon the nation at large that very substantial economies are to be realized by the adoption of mechanical facilities wherever possible for the handling of materials in bulk. It costs something to move any weight any distance, whether the span be a foot or a mile, and manual effort in any case is more expensive. It is plain that much can be gained by recourse to pneumatic carriage, especially where the line of travel is one that would impose troublesome complexities of interchange if some other medium of conveyance were contemplated.

It is announced that the production of sugar in Italy last year exceeded 2,000,000 quintals (1 quintal equals 220.40 pounds), whereas the previous year it was only a little more than 1,000,000 quintals.

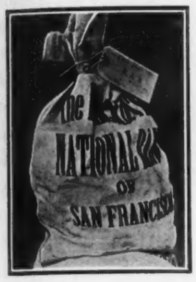


a, Compressor. b, Air reservoir. c, Coal discharge. d, Coal washery. e, Settling tank. f, Conveyor. g, Centrifugal separator. h, Co bunker.

The Present Status of the World's Gold and Silver Production

A Historic and Economic Review of the Precious Metals — The Anomaly of Gold Production and the McFadden Act—The Anomaly of Silver Production and the Pittman Act—Some Gold Theories

By RICHARD HOADLEY TINGLEY



A VARIETY of circumstances have combined, during the past few years, to make the subject of gold and silver of more than ordinary interest. We see a constantly increasing supply of gold money pouring into the country from all quarters of the globe to the depletion of the treasuries of other lands so that now the United States holds more of the yellow metal than any single nation ever before held at one time. We read learned essays by economists who tell us that this gold is a menace to our national well-being and should be disposed of—redistributed—as soon as possible, while, on the other hand, equally learned economists would have us believe that we should hold fast to our golden hoard.

We see gold and gold certificates no longer in circulation and gold coin and bullion heaped in the vaults of the Federal Reserve banks. We see the mining of gold, not only in this country but the world over, declining for the apparently anomalous reason that there is no money in it, and we wonder if Congress will pass the McFadden bill which seeks to subsidize gold mining. In the face of this condition we see a constantly increasing use of gold in the arts and manufactures: in jewelry, ornaments, and in dentistry. We have seen the price of every commodity known to human desire soar to un-heard-of heights, and decline again to more reasonable levels while the price of gold, measured in dollars, remains fixed where it has been through generations of inflation and deflation—its value in purchasing power as fickle as the wind.

We see silver mining, declining in the United States for some years past as it has been the world over, now on the increase in this country, and we know it is the result of the anomalous condition created by the provisions of the Pittman Act which has artificially made the mining of this metal profitable by fixing a price for the native product far above that of metal of foreign origin. We miss the big silver "cart wheels" because we, particularly if "we" are from the West, like them, knowing all the time that the actual value of silver they contain is hardly more than 80 or 90 cents and that it has been as low as 40 cents but a short time ago.

It is to tell the tale of gold and silver, insofar as the brief space of a magazine article will permit, that this story is written.

WHAT BECOMES of all the gold and silver that is mined? What has been the effect of the money supply—of gold and silver upon the economic conditions of nations and peoples?

Records show that since the discovery of America there has been produced in the entire world about $18,000,000,000 of gold. About half of this is now in use as money.

This nine billion dollar nugget upon which rests untold billions of the world's paper money, can be visualized as represented by a cube with dimensions of 22 feet weighing about 18,000 tons.

In this article are discussed gold and silver production, past and present, and also economic phases of the present situation of these precious metals.

A Little Metallic History

From Biblical times to the present day the history of nations and of peoples teems with accounts of its gold—for gold has stood for money, for value, throughout all ages. Occupying only a slightly less important place where money or value is concerned, silver stands out prominently. Every ancient civilization made use of these precious metals as money and their decline and decay are easily read with the exportation of the metals, or a curtailment in the output of the mines from which the supply was drawn. The accumulation of the precious metals by the ancient Oriental monarchs was undoubtedly enormous. Alexander the Great is credited with gathering in the huge amount of $350,000,000 in gold and silver on his conquering career, and the treasure of Ptolemy Philadelphus amounted to $900,000,000. Jacobs, in his "History of the Precious Metals," estimates the amount of gold and silver in the Roman Empire in the year 14 B. C. at $1,800,000,000 and that, owing to abrasion and other losses, together with the drain to the East and a cessation of mining, the amount had fallen to $450,000,000 at the fall of the Empire.

Throughout the Dark Ages mining of the precious metals was prosecuted on but a limited scale which, from the time of Charlemagne to Columbus, varied, according to Edward S. Meade, between $150,000,000 and $200,000,000. The enormous stock of the ancients had, apparently, disappeared or been absorbed by the Asiatics who were then, as now, insatiate hoarders of gold and silver. Be that as it may, it is held by most authorities that, in the gold bars and coins of to-day, there is undoubtedly a plentiful mixture of the most ancient minings, the history of whose travels, melts, and ownerships during these ages would be an interesting one if it could be written.

Any information regarding the stocks of gold of the ancients is, to say the least, unreliable. It is only with the discovery of America that gold and silver history becomes authentic and the stream of the yellow metal which poured into Europe for the next two hundred years from the mines of the New World caused the nations to completely rewrite their economics. According to Dr. Adolph Stoetbeer, who tabulated the world's production of precious metals from 1493 to 1885, supplemented by the records of the United States Director of the Mint since that time, the total gold output of the world from the time of Columbus to the end of 1920 is approximately 870,000,000 fine ounces, valued at $18,000,000,000, and of silver, 12,398,000,000 ounces valued then at $16,029,000,000.

Gold and Prices

During all ages the effect of the money supply—of gold and silver—upon the economic condition of nations and peoples has been most marked. As the supply of money increased or diminished, so prices of commodities rose or fell. Rising prices have always been synonymous with prosperity and declining prices with depression. It has always been so and is so to-day. Proof of this is easily read in the history of the depression which prevailed throughout Europe in the Middle Ages when the mining of the precious metals had practically ceased. Because of the lack of money, barter and exchange governed the purchase of commodities.

With the discovery of America and of America's gold and silver, this condition was completely changed. Prices of everything rose and Europe prospered as the quantity of the precious metals increased—from 237,000 ounces of gold and 13,000,000 ounces of silver in the year 1600; to 346,000 and 11,000,000 ounces of gold and silver respectively in 1700; to 572,000 ounces of gold and 28,000,000 ounces of silver in 1900. With the beginning of the Nineteenth Century production fell off with the consequent

decline in commodity prices and generally depressed business conditions till California and Australia, with their new supplies of gold, started the world off again on another prosperous era. For twenty years or more after these discoveries, prices generally rose, but with the decline in the gold output from 1870 to 1885, prices again fell—obeying the law. The period from 1896 to 1914 and 1915 when the World War began to upset everything economic, saw gold and silver production increase rapidly; from 9,784,000 ounces of gold and 157,000,000 ounces of silver in 1896, to 22,670,000 and 184,000,000 ounces of gold and silver respectively in 1915—and all this time prices were rising.

The influence of the war inflation completely overbalanced the power of gold to influence prices. Gold production declined after 1915 both in this country and elsewhere but, until checked by common consent and good sense, prices rose to the highest notch in history. With the continued decline in the production of gold, however, prices have fallen rapidly. This is the world situation. But the position of the United States, holding more than a third of the world's entire stock of gold, is different. There is good reason to believe that this enormous metallic stock will, eventually, exercise its influence—that credits will again expand, and that we shall again see prosperity. It is expected, also, that the good sense of America, having so recently been through one wild orgy of inflation and having come out of it with drooping feathers, will use its gold and its credit with reason.

In order to make the gold and silver situation quite clear I append table A, which shows the decline in the world's gold production since 1915 and table A-1 showing the silver decline in the United States. Also graphs 1, 2, 3 and 4 which illustrate respectively the world's production of gold and silver since 1865, and the stocks of gold and silver in the United States, each year, since 1865.

TABLE A—DECLINE IN WORLD'S GOLD PRODUCTION*

(In Thousands of Dollars)

	United States	Elsewhere	Total
1915............	101,036	369,430	470,466
1916............	92,590	361,587	454,177
1917............	83,751	339,839	423,590
1918............	68,647	312,278	380,925
1919............	60,333	304,833	365,166
1920............	51,098	286,853	337,951

TABLE A-1—WORLD'S SILVER PRODUCTION

From Report of the Director of the Mint

	United States	Elsewhere (In Ounces)	Total
1915.......	74,961,075	103,889,525	178,850,500
1916.......	74,414,809	82,211,712	156,626,521
1917.......	71,740,362	102,447,438	174,187,800
1918.......	67,810,139	129,584,761	197,394,900
1919.......	56,682,445	117,834,969	174,517,414
1920.......	56,564,504	116,656,100	173,220,604

The exact production for 1921 is not yet known at the time of preparing this tabulation. It is confidently predicted, however, that it will be well above previous years.

What Becomes of the Gold?

There has always been much interest manifested in what becomes of the gold that has been so industriously mined during all these years. The fact that approximately $18,000,000,000 in value (always reckoned at a fixed price of $20.67 an ounce) has been mined since the time of Columbus is almost uncontrovertible. To this must be added another large although entirely indeterminate amount which had been in existence prior to that time. In

*From "Federal Reserve Bulletin."

Lowering part of a $15,000,000 silver cargo into a China-bound ship.

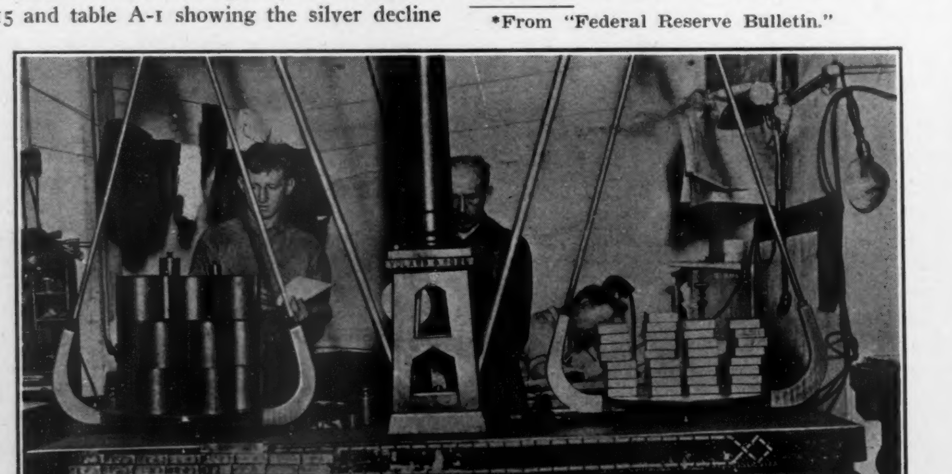
the face of these figures we find from the studies of the United States Bureau of the Mint that only about $8,500,000,000 of gold money in coin and bullion exists to-day in the entire world. This indicates that the quantity of gold metal in use in the arts and manufactures is larger than is generally supposed.

The National City Bank of New York has been conducting a series of investigations in order to determine, as nearly as may be, what has become of the enormous balance. Much of it, undoubtedly, is hoarded in India and other Asiatic countries. Some of it is at the bottom of the sea, consigned to Davy Jones' Locker during the old piratical days. Nobody knows how much. The City Bank says that the known quantities used for manufacturing in the twenty year period, 1890-1910, were slightly more than $2,000,000,000, while the world production in that period was slightly less than $6,000,000,000, suggesting perhaps that as much as a third of the world's output of gold is now being used for industrial purposes.

Asiatic Gold and Silver Absorption

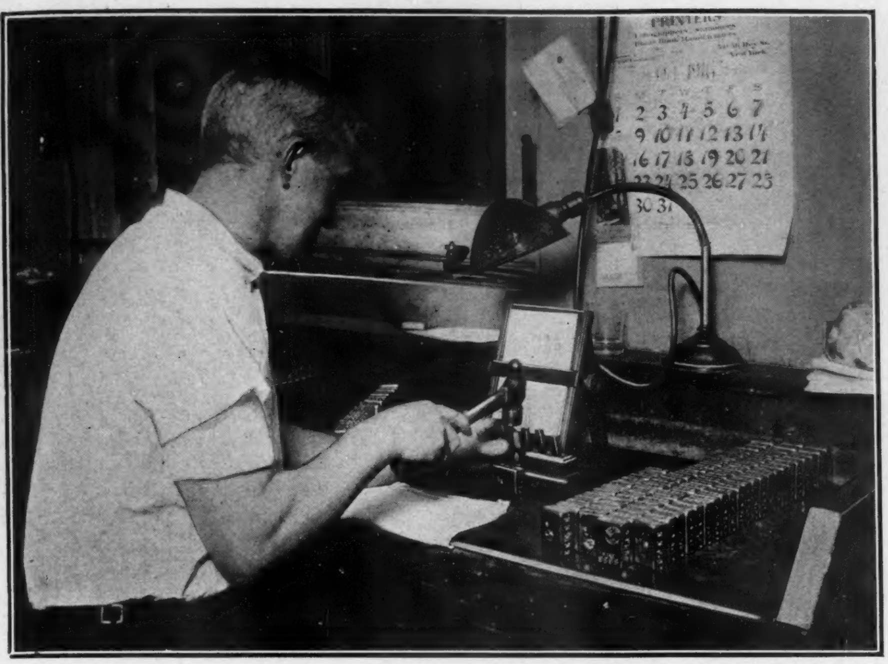
The City Bank seems to demonstrate clearly enough where a third of the gold goes. It is also well established that monetary uses absorb nearly a half of this precious metal. But what becomes of the balance, a huge figure in itself, and the answer seems to point to India and other Oriental countries, and not only do they absorb large amounts of gold, but silver as well.

The net imports of gold and silver into India have been enormous. There has not been a year since 1885 which has not seen as high as 18,000,000 net ounces of the white metal enter that land to stay. In some years the amount has reached a net of 118,000,000 ounces, the average for the past 35 years being approximately 50,000,000 ounces a year. Taking this figure at an average price of, say, 75 cents an ounce, the total for the period would sum up to approximately a billion dollars worth of the white metal permanently taken from other uses —buried—among that vast aggregation of brown peoples. The same conditions have existed with respect to gold, the net imports in



© Underwood & Underwood.

Weighing gold bullion in the New York Assay Office. In the illustration are shown 33 bars weighing 400 ounces each which are weighed to within one one-hundredth of an ounce. The value of the gold on the scales is approximately $270,000. These are called "Certificate" bars and are deposited in the vault to stand behind the yellow-back gold certificates that we so seldom see nowadays.



Courtesy, New York Assay Office.

Stamping gold bars for the jewelry trade. The New York Assay Office sells an average of about $3,000,000 of these bars of fine gold to jewelers every month. Upon each is stamped by hand the serial number, weight and value, together with the official stamp of the assay office certifying to the same. The average weight of the bars is from ten to fifteen fine ounces.

that country amounting to practically $900,000,000 during the 35 year period.

The habit of hoarding gold and silver by the ryot, or Indian peasant, is of ancient origin, dating back to the time when life and limb were unsafe, being constantly menaced by incursions of wild tribes from the North. But habit with the ryot is a clinging thing and centuries of comparative safety have not altered his custom of keeping his valuables always at hand in case a hasty removal of his place of residence is necessary. As a matter of fact, the Indian peasant, individually, possesses but little gold or silver. He subsists on about $30 or $40 a year, but if we multiply his individual holdings and hoardings by the millions of them a goodly amount is reached. By far the greater part of the precious metal reaching India goes into the melting pot and comes out in the form of ornaments. So deep-seated is the affection of all Indian people for gold and silver trinkets that the greater the prosperity of the people, the greater their desire to import them for these purposes. It is a mania among those who can afford it and, although gold and silver ornaments do not draw interest, they are a valuable asset in case of adversity.

Silver and the Pittman Act

The demand of the Orient for silver created a peculiar situation in the world's market for that metal. The United States was looked to in order to supply the deficiency for we were the only country having a surplus. Under the Pittman Act which passed Congress in April, 1918, the Treasury Department has melted down 270,121,554 silver dollars and the bars have been exported to China and other Asiatic countries. The repurchase of silver under the terms of the Act to replace the dollars melted down was begun in May, 1920, when the market price of that metal dropped below $1.00 per fine ounce,—the minimum price provided in the Act for government sales and the fixed price provided for government purchases.

The Act provides for the repurchase of the same quantity contained in the dollars melted, about 208,000,000 fine ounces and, up to October, 1921, only about 73,000,000 ounces have been bought, leaving about 135,000,000 ounces yet to be found. This means that for several years, at least, practically the entire silver output of the United States will go to the treasury at the fixed price of $1.00 an ounce, and that silver mining will thrive. The Government neither gains nor loses by the operation but hopes to stimulate the production of domestic silver by a fixed price sufficiently high so as to make its mining profitable. The irony of the situation, however, is that the price of foreign silver in our market has played all sorts of antics since the government repurchases began—the price going as low as 40 cents last year and ranging all the way from 55 cents to 70 and 80 cents this year.

In order to show the fluctuations in the price of silver, I have plotted graph 5 which exhibits the trend since 1865. On the graph, also, I have drawn the historic line of 16 to 1 which occurs when silver is worth $1.29 an ounce.

Domestic users of silver in the arts are now almost entirely dependent upon the foreign product for their new supplies and the same may be said of the domestic exporters of the metal. Large quantities of foreign silver enter our markets—from Canada, Peru, Mexico and other South and Central American countries in pigs of copper and lead. Consigned to the big refining companies, as the American Smelting and Refining Company, the Raritan Copper Works and the like, it is by them refined and distributed to the metal dealers, merchants, brokers and jewelers.

In spite of the fact that the United States produces between 30 and 40 per cent of the world's silver—this being by far larger in amount than is produced by any other single country—London is, as it always has been, the chief silver market where prices are made for the metal—New York and San Francisco prices always keeping within a very small fraction of that figure. Cleared through London, United States metal merchants often sell to India for Indian consumption or for re-export to China, or to China for their own use or for re-export to India. Comparatively little

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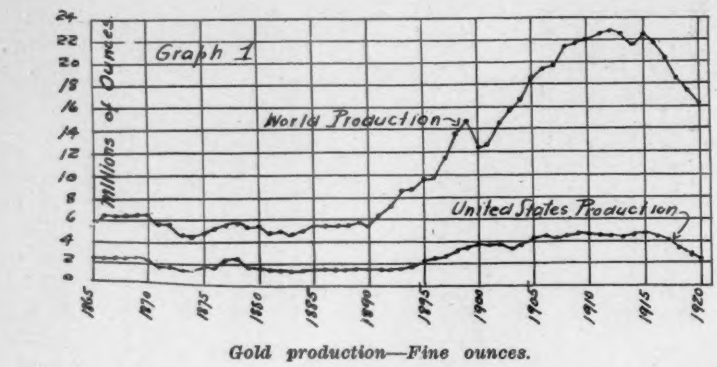
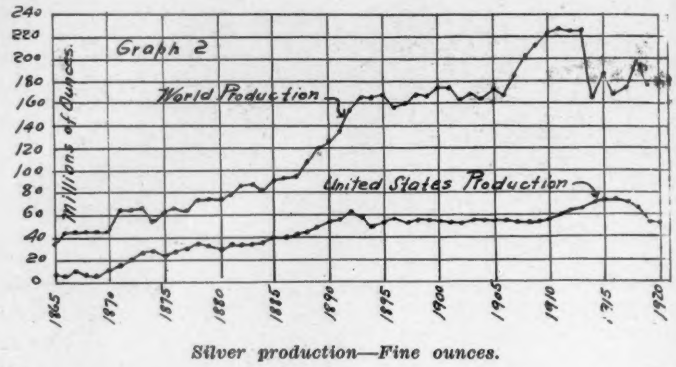
Electrolytic process of refining silver in Government assay office at New York. The anode plates, containing 600 parts silver, 300 parts gold, and 100 parts base metal, are placed in the tanks alongside the cathode plates. The electric current passed through the water in the tanks causes the silver to be deposited upon the cathode plates, the gold remaining, and the base metal falling into the bottom of the tanks in solution.



Gold production—Fine ounces.



Silver production—Fine ounces.

silver, however, is now being exported—the London, Indian and Chinese markets being quiet—in the latter case due to some extent to the exchange rate.

It is generally thought by exporters that a normal demand will soon set in from the Orient for these countries cannot long resist the lure of the possession of the white metal.

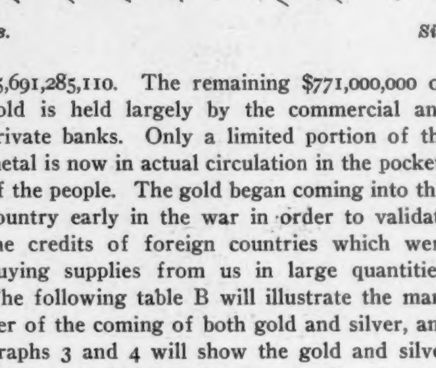
The United States Assay Offices

An important feature in the government's functions with respect to gold and silver and in the relation of the public to Government transactions in these metals are the assay offices, twelve in number. The extent of the business of this branch of the Federal service is seen in the statement of the Director of the Mint in which he says that the total United States coinage value of gold and silver received at these institutions in the fiscal year of 1920 amounted to $254,612,561, more than a half of it coming to the New York office. Also, that the three United States Mints, at Philadelphia, San Francisco and Denver, coined in the above year 733,583,150 pieces of gold, silver, nickel and bronze to the value of $46,446,420 for our government and 18,260,000 pieces for other governments. In the same year these offices exchanged $195,000,000 of gold bars for coin, and $14,000,000 for bullion.

Each of the assay offices and mints is equipped with all the up-to-date appliances and apparatus for the economic refining and assaying of precious metals as the photographs of the New York assay office appended will testify.

Stocks of Gold and Silver

The most recent statement of the Comptroller of the Currency tells us that the total stock of gold money in this country, November 1, 1921, amounted to $3,504,000,000. Of this sum practically $2,733,000,000 is in the vaults of the Federal Reserve banks and stands behind the circulation which amounts, now, to $5,691,285,110. The remaining $771,000,000 of gold is held largely by the commercial and private banks. Only a limited portion of the metal is now in actual circulation in the pockets of the people. The gold began coming into this country early in the war in order to validate the credits of foreign countries which were buying supplies from us in large quantities. The following table B will illustrate the manner of the coming of both gold and silver, and graphs 3 and 4 will show the gold and silver holdings in this country over a series of years.



Graph 3—Stock of silver money in the United States.

GOLD AND SILVER MONEY IN UNITED STATES

From Report of the Director of the Mint.

(June 30th). (000's omitted)

	Gold	Silver
1913	$1,867,000	$745,586
1914	1,872,000	753,564
1915	1,973,000	758,039
1916	2,451,000	763,218
1917	3,019,000	772,908
1918	3,075,000	745,747
1919	3,112,000	568,330
1920	2,708,000	548,938
1921, November 1	3,504,000	

The above figures compare with gold holdings in this country of $135,000,000 in 1873, the sum, although constantly increasing as the business of the United States has expanded, did not reach the billion dollar mark till the year 1900. Since that year our gold hoard has been maintained far above that figure.

Gold and Credits

The stock of gold stands behind the commercial credit business of the country which is best expressed by the volume of bank loans and discounts. It is enough, or more than is necessary for the purpose? Let past experience answer the question.

In 1890 the ratio of gold holdings to loans and discounts of all the banks of the United States was 19.4 per cent. Gradually declining, the ratio now stands at 10.8 per cent. The decline will be seen in the following table C.

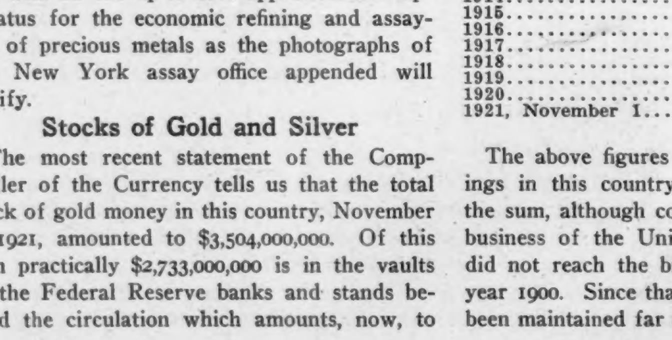
RATIO OF GOLD TO BANK LOANS AND DISCOUNTS

	Per Cent		Per Cent
1890	19.4	1917	14.1
1900	18.7	1918	12.5
1910	13.1	1919	11.3
1915	12.5	1920	8.2
1916	13.7	1921	10.8

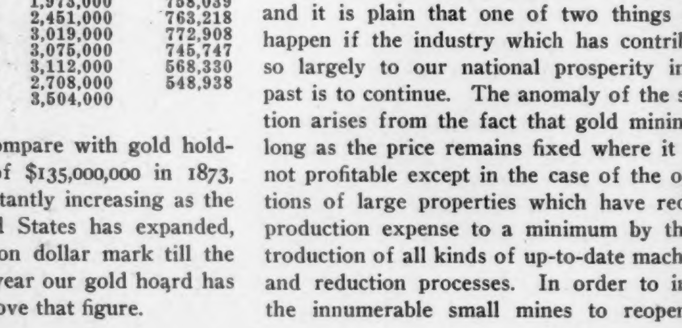
This table makes it clear that, if the business of the country is to expand in anything like the proportion indicated by the experiences of the past 30 years, the present gold holdings will be none too large to sustain it. Indeed it is difficult to see how any of the gold can be permitted to leave our shores if our domestic business expands at all, otherwise the ratio which the safe experiences of so many years has demonstrated to be necessary, will be reduced to the vanishing point.

Gold Mining and the McFadden Bill

Gold mining is declining, as we have seen, and it is plain that one of two things must happen if the industry which has contributed so largely to our national prosperity in the past is to continue. The anomaly of the situation arises from the fact that gold mining, so long as the price remains fixed where it is, is not profitable except in the case of the operations of large properties which have reduced production expense to a minimum by the introduction of all kinds of up-to-date machinery and reduction processes. In order to induce the innumerable small mines to reopen; to

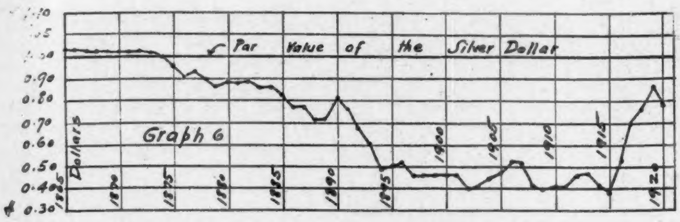


Stock of gold money in the United States.

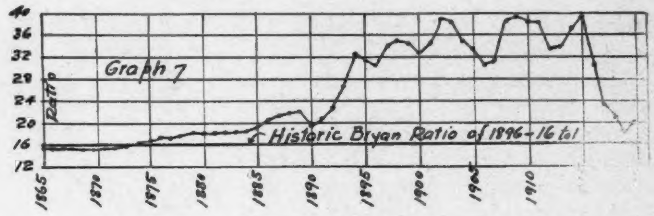


From data by courtesy Director of the Mint.

Price range of silver—Fine ounces.



Actual bullion value of silver in a silver dollar.



Commercial ratio of silver to gold.

start the prospector out again as of old, and to make it profitable for the big dredges to dig up the river bottoms and for the small placer worker to wash out the sands of the many gold bearing rivers, the price of everything else must come down a long way, and when prices fall, depression is rife.

A remedy is seen in the McFadden bill which has long been before Congress designed to subsidize gold mining through the payment of a premium by the Government to miners of new gold. Mr. McFadden claims that, unless a substantial subsidy is granted, the United States will lose its place among the nations as a producer of this metal. It is pointed out that in 1915 this country produced 21.5 per cent of the world's gold and the British Empire, 63.6 per cent. In 1919 the United States produced but 16.6 per cent against 70 per cent of the British Empire. Since the middle of 1919 the British Empire has been paying an exchange premium as high as 50 per cent to the gold producers of South Africa, while in the United States no assistance has been rendered to this industry.

It would be a calamity to see a permanent cessation of gold mining in this country. The investment in gold mining plants, machinery and equipment sums up to enormous proportions and has furnished profitable employment to an army of men. The past generation has seen a marked improvement in methods of handling gold bearing ores and processes of extraction have been so improved by the invention of new machinery and the discovery of new processes that it has been possible to mine gold in veins so low in content that, up to the rise in material and labor costs during the war, gold mining flourished.

Another important factor has been the utilization of compressed air for machine drills and the great improvement in the drills themselves. The early types of machine drills would do as much work as five men using hand drills, but the more recent types exceed these figures at a saving of 50 per cent in power. The diamond drill is another aid to the gold mining industry. Its chief use is in prospecting where, in place of sinking shafts through the solid rock to ascertain the quality of the ore which lies below at an expense which, at great depths would be prohibitive, a small drill hole is sunk and a core is lifted from the rock which enables a sample to be taken in every foot of the rock through which the drill passes. By the use of the prospecting drill the continuity of ore bodies of great depth may be demonstrated at small expense.

That the cost of mining machinery is not, of itself, a serious obstacle to mining operations is evidenced by the following table prepared by A. S. Breakley in *Mining and Scientific Press* which compares the relative costs of metals, materials, machinery and labor.

TABLE D

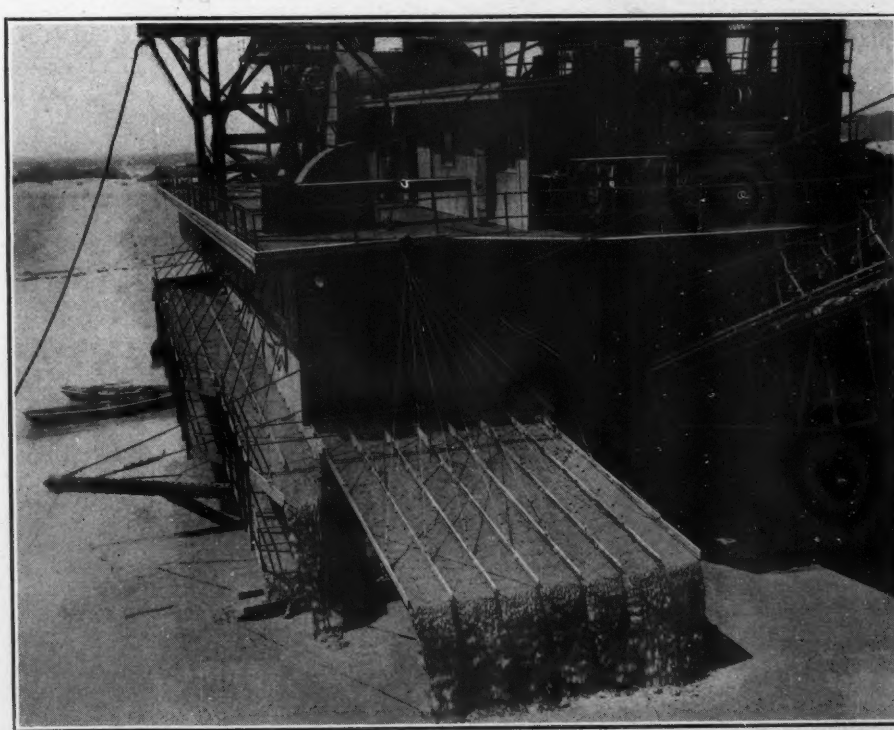
	Metal Prices	Materials Costs	Machinery Costs	Labor Costs
1913.......	100	100	100	100
1914.......	90	92	115	102
1915.......	160	100	130	104
1916.......	182	130	135	105
1917.......	220	170	170	130
1918.......	175	280	175	150
1919.......	150	220	165	185

Some Gold Theories

Although gold and silver have stood for value since the most ancient times the world has never really settled down to a final conviction that either of these metals is useful as money, and some theorists are constantly trying to devise some new form of money—some new method of treating and using that which we have—some new application of the metallic base to credit transactions which a constantly increasing world trade is daily rendering more complicated. They contend that any money base which will permit the violent inflation and deflation periods with which we are all so familiar, is not a perfect base—that a better system should be devised. There are those who believe the world would be better off if all the gold money in the world were dumped into the sea and staple commodities substituted to represent value in some cheap, easily carried token.

It is held in many quarters that the complicated system of foreign exchange might be simplified by the introduction of a universal coinage and currency applicable to all nations. It is held that our system of balancing international accounts by the cumbersome and costly operation of actually transporting the precious metal back and forth around and around the world to meet trade settlements could be done away with altogether, and a central gold deposit be agreed upon by the nations where all the gold money in the world would be permanently lodged, its changing ownership from time to time, from day to day, being indicated with a simple ledger entry by a corps of international bookkeepers. The same thing is now done in our Gold Settlement Fund of the Federal Reserve banks; and why not internationally, they say? But the answer is WAR! When the world has settled down to a permanent Utopian peace basis, such as is hoped will be the final outcome of the limitation of armaments conferences and the naval holiday, such a condition will be advantageously possible—not before.

But years and years of outgrowth and experience have fixed upon and established our present practices with respect to the world's money base and precedent is difficult to change even though something better is shown—a thing which doesn't seem to have yet happened.



Gold dredges make important additions to the world's supply of this precious metal. These large dredges handle, during a year, millions of cubic yards of gravel from which they exact their toll of gold.

COMPRESSED AIR OPERATES QUARRY SHOVEL*

ABOUT A MILE outside of the already famous town of Hollywood, California, hidden away in a narrow gorge known as Brush Canyon, is one of the quarries of the Union Rock Company of Los Angeles. This quarry was opened about January 1, 1921, and operated by hand labor until February, when a Bucyrus 30-B caterpillar steam shovel moved on the job, or rather it was a steam shovel when shipped but upon arrival it was installed for operation by compressed air.

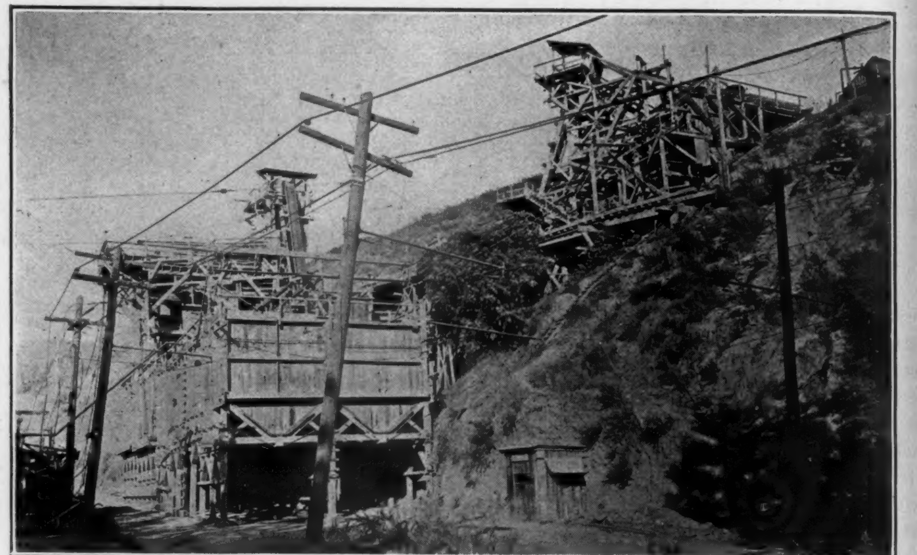
When first opened this quarry was operated by means of an old "glory" hole which opened out at the top of the hill and extended down into it about 50 feet. From the bottom of this "glory" hole a tunnel leads out through the hill to a point about 100 feet up its side and affords the entrance to the quarry. This tunnel is about 500 feet long and before the shovel was installed was just large enough to permit of hauling dump cars from the quarry face to the crushing plant which is set up along the side of the hill below the tunnel.

When the 30-B Bucyrus shovel mounted on caterpillars arrived in February of this year, it was erected at the bottom of the hill and run up to the quarry under its own power, digging its own way by widening an old trail running up the hill at about a twelve per cent to fourteen per cent grade. The tunnel was enlarged to allow the shovel to pass through into the "glory" hole where it has been in operation ever since except when blasting was going on, when it is run back into the tunnel to protect it from flying pieces of rock.

Compressed Air Operation

The most unique feature of the work of this machine is, of course, its complete operation by compressed air. A twelve inch by fourteen inch single stage air compressor is being used which under the operating conditions actually delivers about 430 cubic feet of air per minute at 250 R. P. M. The compressor is driven by an 85 horse power D. C. motor, which in turn is operated by power from a D. C. transmission line a short distance from the quarry. The air from the compressor, which is located on the side of the hill outside of the tunnel, is delivered to a receiver tank which has a volume by actual measurement of 250 cubic feet. The boiler on the machine also acts as a receiver in addition to the tank near the compressor. About one thousand feet of three-inch piping is used to carry the air from the compressor to the shovel at the far end of the tunnel which is about 500 feet long.

*Reprinted from "The Excavating Engineer."



The crushing and screening plant located on the outside of the mountain, and connected with the quarry by a tunnel.

The air enters the machine through the pipe used for water on the steam machine. This pipe is connected through a Barco ball joint to the lower end of the vertical propelling shaft and the air passes through the hollow center of the shaft, thence through another ball joint at the top and through the regular piping to the boiler following the usual path of the water and steam so that no changes in the original steam piping were necessary.

Although this operation has been extremely economical and satisfactory it has been found from experience that the present compressor capacity is a trifle small as there is difficulty in keeping the air pressure at the machine up to the proper point with the present equipment. Under continuous operation the air pressure at the machine drops to about 70 pounds per square inch and the shovel is "logy" and not as quick acting as it should be and is when the air pressure is kept between 90 and 100 pounds per square inch which has proved to be the best operating pressure. However, since the shovel is not loading continuously, this difficulty is not serious, although a larger compressor would be more satisfactory.

Operating Costs

The Union Rock Co. is extremely well pleased with the machine and it has been proved that a considerable saving has been effected over the cost of operation of a steam machine burning fuel oil, which is the usual type of equipment in this section of the country. Under conditions such as these, where cheap power is available and it is necessary to burn oil on account of the high cost of coal, a general idea of the saving effected by using compressed air may be obtained from the following figures:

STEAM OPERATION

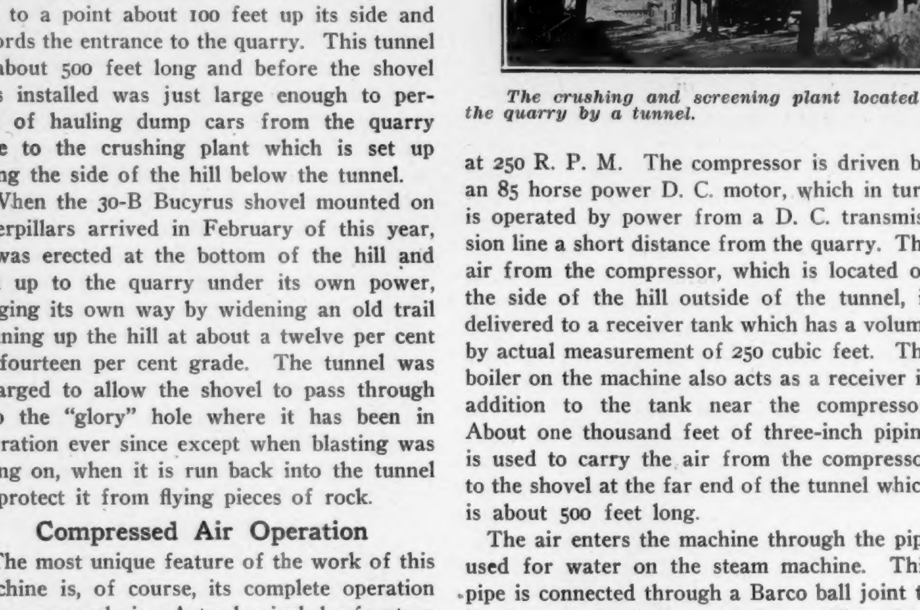
Fuel Oil—4 bbls. per day @ $2.50 per bbl.	$10.00	
Fireman @ $4.50 per day	4.50	
	$14.50 say	$15.00
Monthly cost (26 days)	390.00 say	400.00

COMPRESSED AIR OPERATION

Power at $1.00 per H. P. per month	$85.00
Half salary of compressor operator	65.00
Maintenance and repairs on compressor, Msc.	25.00
	$175.00

Saving per month, $400.00—$175.00=$225.00.

In connection with the above it should be noted that the air for the drills in the quarry is furnished by an entirely separate and independent compressor which requires the attendance of one man anyway, and since the



The compressed air operated shovel dropping a dipperful of rock into one of the four-yard cars. The rock is a tough porphyry.

same man can take care of both compressors only half of his salary is charged to the shovel. In addition the item of $25.00 per month for compressor maintenance, repairs and miscellaneous expense is undoubtedly high. Another point is that there is practically no depreciation of the boiler, and in fact it is probably in better condition than if it were idle because of the oil carried into it by the air and deposited on the boiler tubes.

Quarry Operations

The nature of the quarry operations is very similar to that of any other quarry of the same kind. The rock is drilled and shot around the sides of the "glory" hole in front of the tunnel, and loaded by the shovel after the large pieces have been broken up by blasting.

It might be stated here that the tunnel is of considerable advantage as the shovel is backed into it and kept fully protected whenever blasting is being done.

The material is loaded into four-yard 42-inch gage western dump cars which are pulled out through the tunnel by an electric hoist and dumped directly into a No. 8 Gates, type K, gyratory crusher. From here the rock passes over a scalping screen where the oversize pieces are removed and the remainder passed to a 48-inch Symonds disc crusher. From this crusher the material is elevated to a series of screens and separated by successive screenings to 1¾-inch, 1-inch and ¼-inch sizes. A 24-inch Symonds disc crusher is now being installed to reduce the 1¾-inch rock to smaller sizes by re-crushing. The finished rock is delivered into bins which are elevated to the proper height to discharge through hoppers directly into trucks underneath at the road level at the foot of the hill. There are six bins at present and six more are to be installed.

The daily output in nine hours is about 350 cubic yards which is the capacity of the crushing plant. The shovel is working only about 50 per cent of the time, but in the near future the capacity of the plant will be increased to 600 cubic yards per day, which will mean more continuous shovel operation. The rock is a sort of trap rock and very similar to blue granite. The entire output is used in Los Angeles and delivered by truck, as the plant was originally put in to take care of this local demand under war conditions in order to relieve the demand on the company's larger plants and eliminate freight shipments into Los Angeles. The rock is used mainly for concrete for roads and other construction.

As a result of their experience with this shovel, the Union Rock Company is considering the use of compressed air instead of steam on their railroad type shovels, of which they have several.

To a great extent the successful operation of this plant is due to Mr. Emil Higuera, Superintendent, and Mr. H. Margison who is running the 30-B.

A new ceramic laboratory, in which investigative work regarding the clays of the Northwest will be conducted, is to be installed at the Northwest Experiment Station of the United States Bureau of Mines on the campus of the University of Washington at Seattle.

AIR OPERATED VENTILATION DOORS IN COPPER MINES

By E. D. GARDNER
Mining Engineer

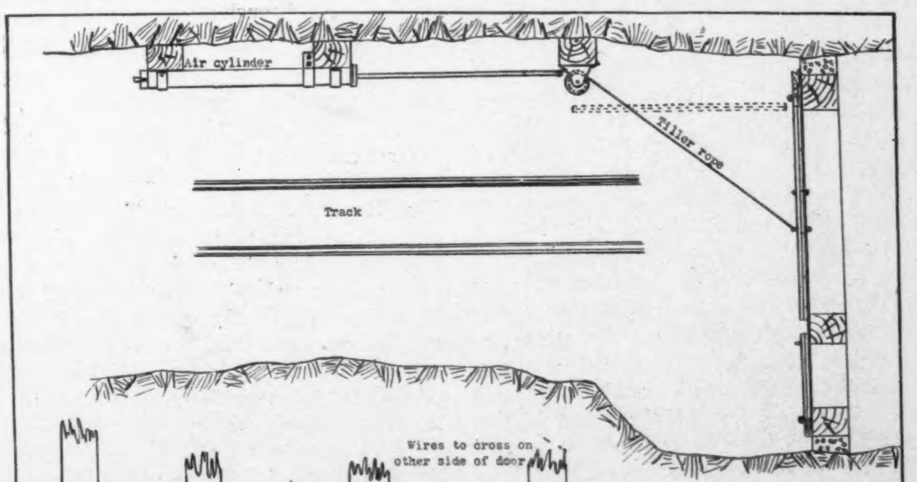
IT HAS ONLY been in recent years that the proper ventilation of metal mines has received serious consideration. Increasing temperature and humidity with greater depth in some of the larger mines of the West prevented the efficient operation of the mines and made the installation of mechanical ventilation systems necessary. Doors that interfere with tramming are generally needed to control properly the mechanically induced air currents and are one of the inherent disadvantages of the system. A number of mining companies in Arizona are using ventilation doors which can be opened and shut mechanically by the motorman without leaving his seat or stopping his train, and thus interfere very little with the transportation of the ore.

The accompanying sketch shows the general construction of the doors at the Calumet and Arizona mine. The doors at this mine are substantially built of two-inch lumber, are air tight, are well placed and have two openings or passageways. The main door, which is used for the motor trains, is five feet wide by six feet high and is opened by compressed air and closed by a counterweight. At the side of the motor door is the main door, which is eighteen inches wide by five feet high and is opened and closed by hand.

The mechanism for opening the main door consists of a section of five-inch pipe about five feet six inches long, threaded at both ends and used as an air cylinder. A piston fits in the cylinder and is attached to a one-inch plunger rod which passes through a stuffing box at one end of the pipe. The free end of the rod is attached to a rope that goes over a pulley and is fastened to the door. A three-quarter-inch pipe connection from the compressed-air line is tapped into the cylinder at the packing end. When the air is turned on, it forces the piston to the other end of the cylinder and thereby opens the door. The door is held open as long as the air pressure is maintained, and is closed by the counterweight and the force of the air current when the pressure is released. The air is turned into the cylinder from the main air line through a three-way cock. Levers placed at some distance from and on either side of the door, are connected to the air cock by two wires. When a train approaches the door, the motorman reaches out and pulls the first lever; this opens the cock, turns the air into the cylinder, and opens the door. After the train has passed through the door, the motorman pulls the lever on the other side which shuts off the air, releases the pressure in the cylinder and the door is closed. The motorman on a train coming from the opposite direction would pull the same levers, but in reverse order, as these are so arranged that the doors are opened or closed by pulling the levers in the direction of the moving train. The distance that the levers are placed from the door depends upon the length and speed of the trains, but should be long enough to give the motorman time to stop his train before it wrecks the door if the mechanism failed to work. At the Calumet and Arizona mine the distance is 150 feet.

A red light is generally placed at each lever and other safety precautions taken. Some doors have been demolished in some of the mines by trains striking them, but with ordinary care on the part of the motorman the use of the doors is safe and no accidents should ocur. None of the doors have been touched by trains in the Calumet and Arizona mine for a number of years.

Abstract from Report of Investigations, Bureau of Mines.



The door is held open as long as the air pressure is maintained and is closed by the counterweight and the force of the air current when the pressure is released.

Compressed Air Magazine

—Founded 1896—

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EDITORIALS

POLITICS AND THE TARIFF

IT IS ONE of the absurdities of our national economic life that tariff issues should have become so mixed with politics that they seem almost incapable of being unscrambled. It was usually a foregone conclusion that when one met a Republican he found an ardent protectionist (in principle) and in a Democrat, an advocate of low tariffs (also in principle).

We knew in advance to a certainty that a change in Federal administration would mean that the tariff must be altered—not necessarily because it needs alteration at that particular time, but because, from time immemorial it had been the practice until it became a habit. The absurdity of the thing is that the tariff is a business and not a political proposition—that the world moves and business conditions change quite irrespective of the changes in the political complection of the country. Tariff issues which were crucial a generation ago or even a few years ago become obsolete, but politics is not exactly as sensitive to these developments as it should be. Party principles call for certain view-points and cannot be easily altered by issues of recent origin.

Among the ranks of the Democrats one finds all sorts and conditions of men; producers of raw materials, manufacturers of every conceivable commodity, jobbers, wholesalers and retailers—men from all walks of business, professional and social life—men whose personal interests lie in protection as well as those whose interests lie in a low tariff. The same may be said of the Republican party. The time has passed when the personal interests of the majority of either party stand preponderantly for high or for low tariff, yet in a purely political line-up, the age-old party traditions are always in evidence. But touch the pocket-book of the most ardent defender of the principles of his political faith good and hard with tariff legislation which interferes with his personal business, even though it conforms with these aforesaid principles and see how quickly he will wake up. He will usually consider himself justified in protecting himself against legislation which he deems inimical to his business interests when new tariff legislation is on, but having succeeded in carrying his point, or having failed to do so, it matters little which—he will be found at the next election right back where he was before staunchly advocating the principles of his political faith.

To illustrate: Everybody knew that if Mr. Wilson was elected in 1912 a downward revision of the tariff would be in order. It was a plank in his platform and had to be. Every producer of sugar in Louisiana knew this and knew, also, that to lighten the duty on Cuban sugar would not be favorable for their business. But this didn't alter Louisiana's solid vote. When the Underwood tariff came up before the Congressional committees, Louisiana sugar men presented their claim and forgetting the traditional principles for which their party stood they succeeded in obtaining a tariff on their chief commodity high enough so they might live in competition with Cuba. That the sugar tariff of 1913—the same which is now in force—was fair and reasonable not only to them but to Cuba is evidenced by the fact that both have thrived under it, and that Cuba is now entering the most strenuous objections to having it altered in any way. But did the menace of a low Democratic tariff alter the political complection of Louisiana? Look at the returns for 1916.

To illustrate again: Everybody knew that Mr. Harding's election would bring to the foreground—true to party principles—a proposed upward revision of the tariff just as soon as the Congressional machinery could be set in motion. Apparently certain of our legislators had not considered that, in the meantime, the greatest war in history had been fought completely upsetting the ancient order of all things economic; that the United States had emerged from its old position as a debtor nation and had become the greatest creditor nation the world had ever seen with all the obligations which accompany such a state; that the outside world owed our country billions and billions of dollars which, if ever paid, must be paid in goods. Everybody knew these things—knew that an upward revision of tariffs would operate to close our doors to imports and thus shut out the only method the outside world had to pay its bills to us. By the same token, also, they knew that future imports must be reduced to a minimum by a high tariff and, if they had their thinking caps properly adjusted, should have known that exports must, of necessity, fall off because of the inability of foreigners to pay in kind—for in kind is the only method of payment whereby it is possible to permanently square international accounts. Knowing these things but true to its principles, the Congress proposed the highest tariff in history—a high protective tariff drawn in the interests of protection of home markets and vouched for by home market associations generally who fear that Europe and Japan will "dump" their products of cheap labor upon our markets and ruin our home industries.

Without going into statistics, there are just as many Republicans as Democrats who do not favor the Fordney tariff as it stands today with its disturbing American plan of assessing duties. That the Fordney bill, as it has left the House, is unpopular there is not the slightest doubt. No tariff measure since the passage of the famous "Tariff of Abominations" away back in 1828 has contained so many drastic upward changes as are now contemplated by this bill with its little understood American plan. Trade association after trade association, chamber of commerce after chamber of commerce and business men's clubs without end have registered their disapproval of the American plan, saying that it will increase the cost of living enormously and completely throttle foreign trade. They have pointed out that the plan was tried in the United States in 1842 and discarded after two months operation, and that it was rejected as unsound by the framers of at least three of our previous tariff acts.

It seems the consensus of opinion among conservative civic and economic bodies that the present is no time to tinker with the tariff, particulary with the introduction of an innovation of such doubtful and untried potentialities as the American plan. It is pointed out that any tariff action under the present unsettled condition of the world's affairs would be unwise, and that to set up new tariff legislation in this uncertainty may bring injury to our own commercial and industrial life far outweighing any advantage which might accrue to individuals and selected groups of industries from the proposed Fordney tariff or of any modification thereof. Frequent tariff changes unsettle business, particularly if business conditions do not warrant a change. At some future time when economic affairs shall have become more stable and business conditions demand, will be time enough to take up the tariff matter again. The time and manner of such revision should rest upon a much more careful and extended study of conditions than has yet been given the subject. This study should embrace a consideration of the tariffs of other countries and their effect upon our interests and upon world economics generally. Congress has equipped itself with the machinery for accumulating such data in the permanent non-partisan Tariff Commission or Board now acting. This Board has no legislative powers and cannot even recommend tariff legislation. It can, however, accumulate data and information—and accurate information is needed more at present than legislation.

Perhaps the present deadlock in Congress will mark a turning point in tariff legislation; that, in the future, it will be business interests and not political exigencies which dominate. The public has spoken in a loud voice and it is just possible that the first step is now being taken which will permanently divorce the tariff from politics.

OVERSEAS COMMUNICATION BY MODERN WIRELESS

ANOTHER LINK was recently added to the great chain of radio plants encircling the earth when President HARDING pressed a key in the White House at Washington and sent a message broadcast from the new station at Rocky Point on the north shore of Long Island. This station equipped with six skeleton steel towers rising 410 feet above the sandy soil of the island with its 25 miles of silicon bronze cables aided by a current of 100,000 volts relayed the Harding message into the ether.

With the speed of light, 186,000 miles per second, this message traveled over the globe in one-seventh of a second and hardly had the signature of WARREN G. HARDING crashed through the sky when responses began to come from every country equipped with a wireless station.

The first reply was received from Norway, next the great station at Nauen, Germany, then followed England, France and South Africa. Included in the responding messages were ones from Japan, 7,000 miles away, and Sydney, 9,000 miles away.

The message from America read as follows:

> To be able to transmit a message by radio in expectation that it may reach every radio station in the world is so marvelous a scientific and technical achievement as to justify special recognition.
>
> It affords peculiar gratification that such a message, from the Chief Executive of the United States of America may be received in every land, from every sky, by peoples with whom our nation is at peace and amity.
>
> That this happy situation may ever continue, and that the peace which blesses our own and may presently become the fortune of all lands and peoples, is the earnest hope of the American Nation.
>
> WARREN G. HARDING.

This accomplishment at the Rocky Point station marks an important step in the development of radio communication across oceans and between continents by high powered stations which bids fair to be even of greater importance than the increasing use of wireless communication between stations on the land where it is supplementing the communication usually performed by telegraph and telephone.

A still further advance in the mechanical art of communication is the radio telephone which must be now recognized as an established fact though its development remains for the future.

No doubt invention will still further perfect the operation of the wireless by reducing the interference in transmitting and receiving messages.

At present the day to day mechanical achievements in the domain of practical aeronautics occupy the foremost place in the popular estimation of the public because of their recognized importance, but the victories won in the field of radio communication are of the highest significance. They possess vast possibilities and because of the international influence of such accomplishments the radiotelegraph or the radio telephone of the future will play a very vital part in deciding the affairs of the political and business world.

CHANGING POLICIES OF THE RUSSIAN GOVERNMENT

IN A RECENT issue of the "Novy Mir" the Russian "Soviet" Premier LENIN was reported to have stated in the course of a speech, that unless every bourgeois technical and business expert in Russia got to work to develop industry, and the Russians demonstrated their ability to work for themselves, the "Soviet Republic" was doomed to ruin. Furthermore, the "Foreign Capitalists," who are being invited to accept concessions in Russia would endeavor to exact several hundred per cent. interest out of the workers. "But they will teach you how to work, and when you learn the meaning of real work, you will be able to create a pure communistic economic system."

This is another indirect admission of the real weakness of the Bolshevik regime; viz., the refusal of the workers themselves to make a go of communism. So long as there were accumulations—other people's accumulations—of property to be divided up there was little difficulty in maintaining enthusiasm for the cause. But when communism resolved itself into starting in to produce wealth, or values, or property, or whatever else you want to call it, for the commonwealth, instead of for the benefit of the producer, the workers and peasants as a class could not be induced or forced to buckle down to normal production. This situation can hardly be called an organized strike or rebellion; it was merely human nature asserting itself.

When talking for home consumption the Bolshevik leaders bitterly denounce the "Bourgeois" as a class for "refusing to work." When talking for foreign sympathy and to secure financial aid, another side of the picture is presented. Here the "intelligentsia" (and Bourgeois) are portrayed as doggedly attempting to "carry on," conducting their labors in unheated rooms, wearing their overcoats and hats to keep warm, doctors and nurses working eighteen hours a day in unheated hospitals, without medicines, disinfectants or surgical dressings and surgeons performing operations without anesthetics. All this without sufficient nourishment (and what they don't say, in constant danger of arrest and imprisonment or execution without trial), and hampered and hindered at every hand by "ignorant and bigoted officialdom."

As a matter of fact, there are few "Bourgeois" or members of the "intelligentsia" in Russia to-day who are not working and striving to bring about a betterment of conditions within the confines of their homeland. That their efforts are often, very often, in fact, unavailing is largely due to the apathy of the so-called workers.

Would any informed person to-day assert that the Soviet regime had stood as long as it has, thanks to peasant support? Or support of the actual workers?

It would appear that once a "worker" accepts communism, he is eligible to membership in the "ruling class" and promptly sets about landing a government job, where he ceases to be a producer and becomes a parasite. In a sense the soviet is a "worker's" government, but with the addition of the prefix "ex." The leaders, whose eyes have long been open to this condition, were powerless to bring about a change so long as they adhered to their original principles. The irreconcilables seemed to believe that if communism interfered with the nation's business, give up the business—but this works just about as well as the same idea applied to whiskey. Therefore LENIN has been talking to the irreconcilables of late, and talking pretty straight—and this time his remarks have the appearance of being for consumption both at home and abroad.

Since last August new decrees have been issued almost every week, and they all appear to be reverting to the "old way," i. e., capitalism. For example, payment of rent, train and train fares was abolished as of Jan. 1, 1920, but was again reinstated by decree as of Oct. 1, 1921. In keeping with this abolition of free service, wages have been increased—for example clerical workers have been advanced from Rs. 4,000 per month to Rs. 60,000 per month, but one naturally asks how much is a ruble worth under these new conditions? Early in August before the changes went in to effect, the dollar on the "Moscow Exchange" was worth about Rs. 80,000, whereas in the middle of November it was quoted at Rs. 200,000. According to our values, the new salary of Rs. 60,000 would not be much to boast about. See how it works out internally, according to Russian values: In August a pound of bread could be bought for Rs. 4,000 (one month's pay at that time); butter for Rs. 30,000 per pound; sugar Rs. 28,000 to Rs. 30,000; pork Rs. 15,000; bacon Rs. 25,000; salt Rs. 4,000; soap Rs. 10.000. On the same day that the dollar was quoted at Rs. 200,000. bacon was quoted at Rs. 90,000. In other words, where a worker could formerly earn a pound of bacon (according to the official wages paid) in a little more than six months, in November but six weeks labor was required to acquire the same luxury. This is an improvement, even if very slight.

We are informed that in Petrograd there is now plenty of food, but the prices are quite out of sight. Needless to say no one can or does live on their official salary; they all find some kind of business to do on the side, formerly on "QT" and now in the open. This "business" may only consist in disposing of a few remaining possessions—but now it is not accompanied with the same fear of apprehension and imprisonment. That also is a certain measure of relief.

Possibly the "foreign capitalist" will be able to "teach them how to work" in time—but

it is going to be a tremendous task to get under way and create a desire to work. It might not be a bad idea for the government to take a "Supervision holiday" and try to make work a little more attractive to the masses.—*W. A. M.*

COMPRESSED AIR AIDS IN CURE OF TUBERCULOSIS

SCIENCE has been at work with the compressed air treatment known to physicians as the "artificial pneumo thorax," in which undiluted air, or nitrogen gas, has been used as the agent. It has been discovered that men afflicted with tuberculosis, who have gone down to work in the water-sunken caissons of the Dravo Construction Company of Pittsburgh, and who have been subjected to working conditions in compartments of compressed air, instead of showing an aggravation of the disease have gained weight and strength.

The first tests of compressed air treatment in this country were made by a doctor in Silver City, N. M., and a noted group of specialists are giving the compressed air treatment serious consideration at Saranac Lake Hospital. Dr. Alexander, formerly of the United States General Hospital, Asheville, N. C., says the treatment is given credit for beneficial results in both tuberculosis and in pneumonia. A cubic foot of compressed air contains more oxygen than a cubic foot of free air. Desert air is dry air and has long been considered beneficial in the treatment of tuberculosis patients. Compressed air is also dry air. The men in the caissons therefore may have benefited both from the dryness of the air and from the extra supply of oyygen.

AT LIFE'S LATEST MILESTONE NEW YEAR'S 1922

OUR CLOCKS all strike the hour which just has passed;
So should Life's milestone mark the year complete
And not the year begun; but who e'er thought
Or spoke of Old Year's Day, though such it is.

What could we do without these markers set
So regular and sure along the way?
At this one here we'll for a moment stop
And have some chat about what happened as
We came along the rough and toilsome road
We trod of late, with such scant chance to rest.
And sure we need a rest to tell ourselves
At least how tired we are and brace us each
To face the toils we know we still must meet,
And bid our hopes assure us in advance
A straighter, smoother road, with genial skies
Predominant.

The life of the great world
Is surely automatic, working out
A plan of constant betterment, and this,
When wide and far we turn our backward gaze,
We dimly recognize, but when we peer
Out o'er the road in front our vision fails
Although we must be sure the plan yet holds,
The future still improving on the past.
Some things we've learned of late, and not the least
How small indeed the individual man
In Life's great scheme. A plaything of grim war
Which dashes on us ere we are aware
With circumstance we can't anticipate,
And makes its terrors real in our lives
With wholesale desolation, death and woe,
And whelming sorrow to life's latest breath
For millions untold.

To find some good
In any raging war, or one whose scars
And gashes still are raw, is such a task
As few will even dare attempt, and yet
It is not far to seek. No active cause
Is single in effect, but also does
Some other thing than that most evident.
What if stern war while straining hard to kill,
Upset, destroy, within a given field
And for a fleeting time, is working out
For all the world for ages yet to come
Some problems that our smoothest years of peace
Have been perplexed with?

Humming industry
Did hum too loud, the wheels spun round too fleet;
Accumulation turned our "goods" to "bads"
Almost, because we could not, or let's say
We did not, learn to use them for ourselves.
A curious sight it was, which no one seemed
To think incongruous, the circle wide
Of nations boasting their efficiency
Yet each attempting most industriously
To pass its products to the next, and each
Exulting not at all to get the good
Of its own goods, but in the magnitude
Of its "unloading." Such a game as this,
However long to last, how could it lead
To any comfortable ending, or
To easy satisfaction all around?
So far as we could see, the path led straight
From bad to worse with not a single turn.

Of those who saw what we were coming to
In all these troubles, not a thought of war
Occurred to any one as the way out.
The remedy should be commensurate
With the disease, but diagnosis failed
To carry us so far along as that;
Yet still we must believe the Great World Plan
It was that brought us the World War
To help to set us right, and show us all
The Great World Road a little farther on.

For all that we now see, the very things
Thus far accomplished only tangle up
And mix us all the more. Our idle hands
Hang useless when we would be hard at work
And have the wheels all whirling as of old.
Full sure we know the work that must be done
Is piling up before us, if we could
Begin a sane resumption. Puzzled sore
We are to find and plan good work for all.

We needs must think of waiting public works,
Constructions vast and permanent to serve
The constant needs of massed humanity.
These weary years have paralyzed their growth,
And much that's been destroyed must be replaced,
Which leaves us all, in this one field alone
Far in arrears. Conditions similar
Rule all along the line of industries
Which were our daily life and sustenance.

To pick up the old threads and weave along
The pattern that we knew is our first thought,
But that can never be. There's no such thing
In life. The ante bellum status quo
Is never found again, however much
We seek it. War has shown us much to learn.
When soaring wages taught extravagance
Extravagance did also teach
Some lessons not so soon to be forgot.
Cash taught the many money gets the goods,
And so the goods came into many lives
To soon become the habit. Luxury
That was is now necessity that is.

Thus has America in days of stress
Been cultivating customers at home,
And they are best of all. Our goods produced
Are better sold to neighbors near than sent
Across the sea, avoiding all the waste
And loss of money or of money's worth
In transit back and forth.

And this suggests but one of many ways
In which we're learning fast the good of goods
To use ourselves. The farmers, all spread out
From sea to sea, from Lakes to Gulf, find price-
Increase of goods which they produce the same
As was the wage-increase of those whose toil
Is measured by the day, and they too call
For more and buy much more like all the rest.

The race the "white" man once called slave is now
Fast coming to its own and spreading out
Into the broader life. Sure none can come
More helpful to our market stalls than they,
And they are numerous enough to count.

There is one question upon which
We will not all agree. We did consent
To let the good and wise ones have their way
To kill the habit of excessive drink.
The doctors, as some say that doctors do,
Perhaps did cut so far "beyond the wound
To make the cure complete" that none can tell
How well the patient will be when he's cured.
But here we can agree again. To stop
The money waste that went to the saloons
Must leave large sums to use for better things
The total looming large.

But we must stop
Nor let encouragement climb up too high
And topple over. When the war was on
We talked preparedness, and now with peace
We need it as we never did before;
It must be lasting and most strenuous,
And optimism will be glorified.

FRANK RICHARDS.

We desire to express our acknowledgment of the courtesy extended to the COMPRESSED AIR MAGAZINE by the Monongha Glass Co. and the Gill Glass Co. in securing photographs of the various operations in the manufacture of glass which were published in the December issue.

CAMS—ELEMENTARY AND ADVANCED by Franklin DeRonde Furman, M. E. Professor of Mechanism and Machine Design at Stevens Institute of Technology. Illustrated with 182 figures; 234 pp. 6x9; price, postpaid, $3.00 net. New York: John Wiley & Sons, Inc. London: Chapman & Hall, Ltd.

THE SUBJECT of cam design is presented clearly and completely, the processes of design being mostly graphical are readily followed by practical shopmen and draftsmen as well as technical students. The chief original features of this advanced book include the development or use of the logarithmic cube, circular, tangential and involute base curves, the establishing of cam factors for such of these curves as have general factors, and the demonstration that the logarithmic base curve gives the smallest possible cam for given data. Comparisons of characteristic results from all base curves in which are given the relative size, velocity and acceleration of each are shown graphically, enabling the designer to quickly select the type best adapted for the work in hand.

THE FUNDAMENTALS OF ACCOUNTING, by William Morse Cole, A. M., Professor of Accounting in Harvard University, author of *Accounts: Their Construction and Interpretation*. Price $3.50. 430 pp., indexed. New York: Houghton, Mifflin Company.

EVERY PERSON charged with executive responsibility should know the fundamentals of accounting for he cannot understand the reports of his own business (if he has a good accountant) unless he knows what the accountant is talking about. He cannot direct even elementary accounting (if he has not a good accountant) unless he knows what constitutes good accounting. Every student of public affairs should be able to interpret financial reports, both public and private, and know what business facts lie behind them. The study of accounting, therefore, is not futile even for those who cannot be accountants. It is with this thought in mind that the author has proceeded in dealing with accounting fundamentals.

The method of the book is, as the author states, best described as philosophical. It starts with the simplest obvious facts needing record, property and ownership, and from this develops the need of particular accounts. Not for several chapters is any need found for the always confusing nominal accounts, and then they are developed after need for them has arisen. The technique of bookkeeping does not appear until the ninth chapter, and then its results as labor-saving devices become necessary. The whole method of procedure is based on the fact that nothing is of interest until there is some need of it, or curiosity about it, is felt. All the fundamental considerations of accounting are thus gradually developed.

The selection of material and the method of explaining are the result of twenty years of university experience by the writer in teaching accounting as well as from considerable experience in the practical end. The combined viewpoints of the instructor, the student, and the practitioner are thus brought to the aid of the reader.

To illustrate the principles worked out, every chapter has appended a list of questions and problems which test the reader's ability to apply the principles to concrete facts. The desire is that accounting must not be taken as if it were a collection of facts to be memorized, but rather a subject which must proceed by reasoning and not by rule.

THE EVOLUTION OF THE OIL INDUSTRY. By VICTOR ROSS. A description of the industry including its uses in ancient times, during the war, under present conditions and the part pe troleum will play in the future industrial situation. Price, $1.50; 178 pp.; illustrated. New York: Doubleday, Page & Co.

LIKE THE MIGHTY industry which it describes, this book is a blend of romance and cold facts. There have been myths about oil farther back than recorded history. Mr. Ross tells some of these strange, alluring tales. He then gives the history of the rise and growth of the industry in this country from the time the first well was drilled by COLONEL DRAKE in Titusville, Pa., in 1859, until the present day.

We quote the following paragraph from the preface written by DR. VAN H. MANNING, Director of the Division of Technical Research of the American Petroleum Institute and formerly Director of the Bureau of Mines of the Department of the Interior:

"A glance at the chapter headings in this little book shows that it is an endeavor to present in succinct form a survey of a great and ever expanding economic revolution—the interpenetration by petroleum of all industries whether of the factory or the field, land or sea, war or peace. This phenomenon has been almost exclusively a development of the last six decades, and the United States of America has been the predominant factor in the innumerable changes wrought thereby."

The development of systematized methods in discovery and location, transportation and distribution, in fact every stage from the moment oil is "struck" to the placing of any one of the very many products of crude petroleum in the hands of the consumer are described in a most interesting and instructive manner.

Mr. Ross concludes his valuable contribution to this subject by tracing the growth of the oil industry throughout the world and the dominant part it is playing in the destinies of nations to-day.

According to Charles A. Munroe, president of the American Gas Association, there are more than 1,000 artificial gas companies supplying 4,600 cities and towns and furnishing the cooking fuel in the homes of 55,000,000 people, as well as heating and industrial requirements to thousands of factories. The gas companies yearly turn more than 10,000,000 tons of coal and a billion gallons of oil into clean, economical and dependable fuel.

TWO UNUSUAL BOOKS ABOUT OIL AND STEAM ENGINES

THE SUBJECTS of Stationary Steam Engines and of Oil Engines (Surface Ignition Type) are treated in a very interesting manner in two new publications from the Vacuum Oil Company, New York. The pamphlets are handsomely illustrated books of 32 and 22 pages respectively, the size being nine by eleven and one-quarter inches. The illustrations are all very instructive, in many instances being made particularly so by the use of three and four colors to distinguish the various features or operating principles of the machines. Both booklets are technical presentations of the construction, operation and lubrication of the two classes of machinery; prepared very concisely and lucidly.

The books cover briefly the Classification of the Machines, Factors of Operation, Mechanical Principles and Lubrication. In connection with Stationary Steam Engines, the subjects of Boiler Plant and Steam Production are dealt with, such factors as Steam Quality, Exhaust Steam, Oil in Exhaust Steam and its Extraction and Feed Water Treatment various departments of the subject discussed.

Both books may be obtained upon request and are sure to be of value to both individuals and concerns.

The Davis-Bournonville Co. of Jersey City, N. J., has issued an illustrated bulletin describing tube welding machinery and fabricating equipment. This bulletin includes listing machinery for producing welded tubing from commercial steel sheets, or rolled strip stock, and copies will be sent on request to interested customers.

New Mining Publications

THE BUREAU OF MINES of the Department of the Interior has published the following new bulletins and technical papers:

Technical Paper 249. The determination of oxides of nitrogen, by V. C. Allison, W. L. Parker, and G. W. Jones. 1921. 13 pp., 2 figs.

Technical Paper 261. Oil-camp sanitation, by C. P. Bowie. 1921. 31 pp., 3 pls., 4 figs.

Technical Paper 291. Production of explosives in the United States during the calendar year 1920, with notes on mine accidents due to explosives, by W. W. Adams. 1921. 44 pp., 3 figs.

Technical Paper 293. Coke-oven accidents in the United States during the calendar year 1920, by W. W. Adams. 1921. 32 pp.

Bulletin 186. Investigations of zirconium, with especial reference to the metal and oxide, historical review, and bibliography, by J. W. Marden and M. N. Rich. 1921. 152 pp., 2 pls., 3 figs. 25 cents. For sale by the Superintendent of Documents, Government Printing Office, Washington, D. C. Not sold by the Bureau of Mines.

NOTE—As the supply for free distribution is limited, applicants are asked to cooperate in insuring an equitable distribution by selecting publications that are of especial interest. Requests for all papers can not be granted. Publications should be ordered by number and title. Applications should be addressed to the Director of the Bureau of Mines, Washington, D. C.

The election of Arthur Lucian Walker, professor of metallurgy in the Schools of Mines, Engineering and Chemistry of Columbia University, as a member of the Board of Engineering Foundation, which is organizing industrial research on a nationwide scale, was announced recently by the chairman of the board, Charles F. Rand of New York. Prof. Walker succeeds Dr. Joseph W. Richards of Lehigh University, who died recently.

* * *

Mr. Frank Porter, F. W. Schroeder and Mr. J. E. Walters who have been stationed at the helium plant at Petrolia, Texas, have been transferred to Washington where they have been added to the cryogenic laboratory.

* * *

Mr. James F. Deimling, assistant chief engineer of the Michigan Central, has been promoted to chief engineer with headquarters at Detroit, Mich.

* * *

Mr. K. L. Warburten, formerly identified with the Celtic Products Co., has accepted a position with the Quigley Furnace Specialties Co.

* * *

Dr. J. F. Brewster has been appointed research chemist at the New Orleans Experiment Station.

* * *

Mr. Axel S. Vogt, formerly mechanical engineer of the Pennsylvania Railroad, died in Philadelphia recently, age 73 years. Mr. Vogt worked his way up from the position of draftsman to the position he held when he died.

* * *

Mr. Chas. K. Mallory, formerly chief engineer of the Solvay Process Co. of Syracuse, N. Y., has been appointed manager of the dry dock section of the Emergency Fleet Corporation.

COMPRESSED AIR AT WORK ON LONDON BRIDGE

By ROLAND H. BRIGGS

IF THE INHABITANTS of Britain who fled across London Bridge in the year A. D. 457 from the invading Saxons had seen a triple-headed monster biting off a foot of solid concrete as easily as cheese, its three horrid heads belching compressed air as it fed and its long snakelike coiling necks leading back to its quivering body, where its partly visible internal organs worked at terrific speed in the apparent endeavor to digest so hard a fare, they would probably have turned back into the arms of the invaders rather than face so fearful an apparition as that which was recently at work on the northern approach to this historic bridge.

But now even the most bloated profiteer barely turns in his car to see what has disturbed his mind from the congenial problem of how best to do his fellow-men, and the passing crowds of all colors and races only give a lingering glance at the Ingersoll-Rand air drills which have replaced the rythmic but laborious method of concrete breaking with the wedge and sledge hammer.

London Bridge, in the repair of which modern pneumatic methods have now been enlisted, is historically perhaps the most interesting bridge in the world. There are many more famous bridge engineering achievements, many larger, higher, longer, more beautiful and more mechanically perfect bridge constructions, but few are more ancient and probably none has had a closer connection with the modern development of the human race.

London Bridge was built at the point where the vast swamp in which the Thames River ran narrowed down on the northern shore to a point quite near the main river channel. In the first century and probably much earlier London was a great commercial resort, but at that time business was carried on at what was probably only a summer fair, and the locality was deserted for the rest of the year.

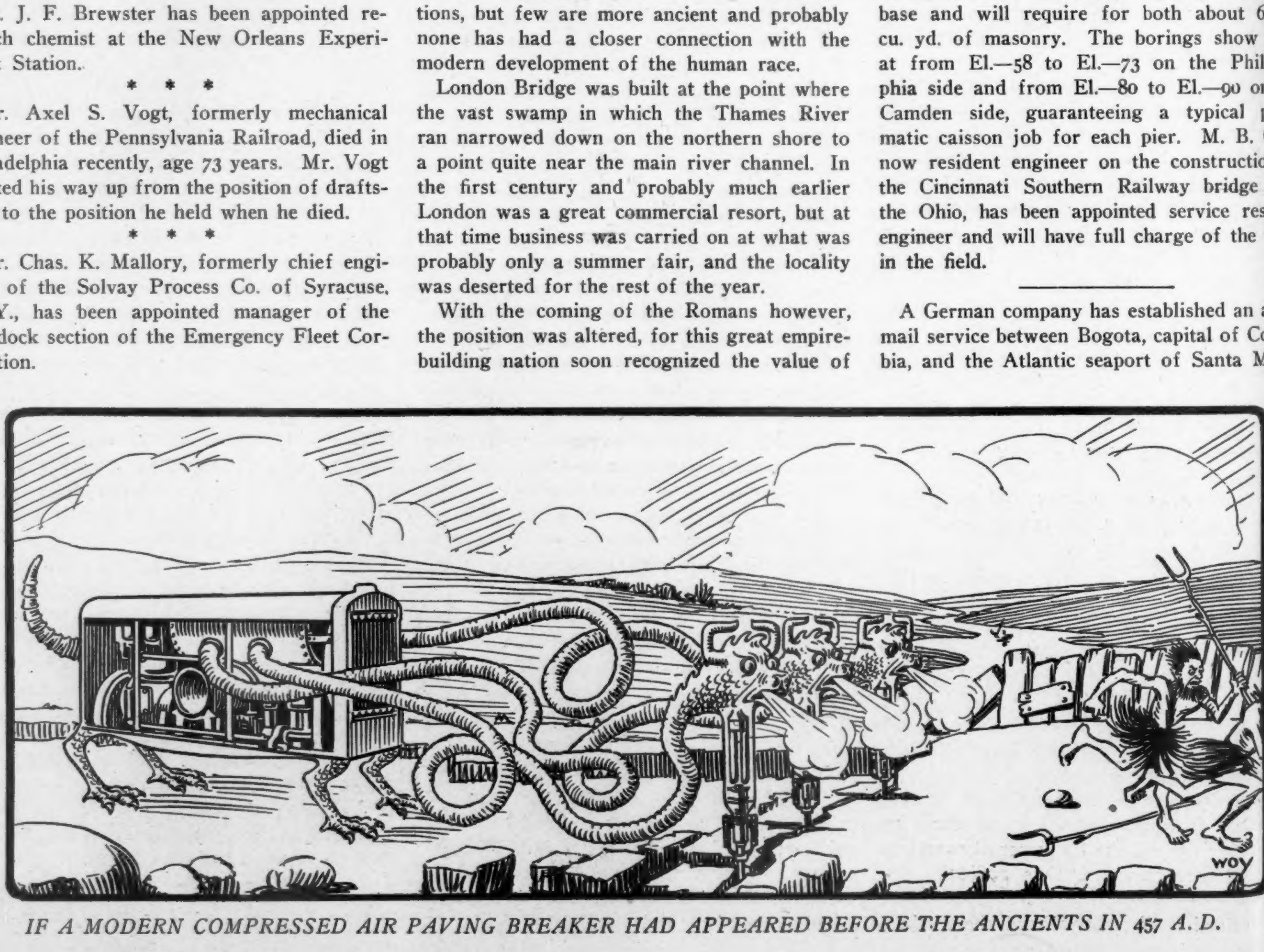
With the coming of the Romans however, the position was altered, for this great empire-building nation soon recognized the value of the site of the present city, built a fortress on it, connected their main roads to it, and constructed the bridge across the river, as a political and commercial convenience in time of peace and a line of retreat to Gaul in time of war. At the present time, fifteen or sixteen centuries later, the modern stockbroker uses it in the same way to retreat from the no less savage though bloodless battles on the Stock Exchange, situated within a few hundred yards of its northern extremity.

London Bridge is still the greatest business thoroughfare in business Britain, as it has been ever since its inception in the time of the Romans. It carries by far the largest number of pedestrians and traffic into the very heart of the city. In the past it had shops built upon it so that business was done on the actual bridge itself. It is the western end of the port of London, and the discharging and lading of vessels is in constant progress in the very shadow of the bridge. The present concrete and granite cased structure was completed in 1831. The bridge which it replaced was constructed in 1207, but the exact date of the original Roman bridge is lost in the mists of antiquity.

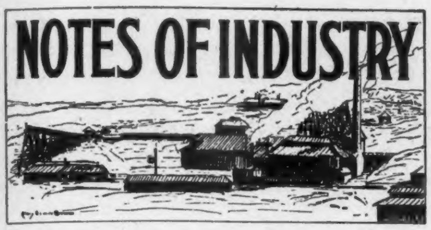
THE PHILADELPHIA BRIDGE

Formal approval of the plans for the great suspension bridge across the Delaware River at Philadelphia has been given by the Secretary of War and Chief Engineers, U. S. Army. The piers will measure 70 by 143 ft. at the base and will require for both about 62,000 cu. yd. of masonry. The borings show rock at from El.—58 to El.—73 on the Philadelphia side and from El.—80 to El.—90 on the Camden side, guaranteeing a typical pneumatic caisson job for each pier. M. B. Case, now resident engineer on the construction of the Cincinnati Southern Railway bridge over the Ohio, has been appointed service resident engineer and will have full charge of the work in the field.

A German company has established an aerial mail service between Bogota, capital of Colombia, and the Atlantic seaport of Santa Marta.



IF A MODERN COMPRESSED AIR PAVING BREAKER HAD APPEARED BEFORE THE ANCIENTS IN 457 A. D.



Employing co-operative funds furnished by the State of Missouri, an investigation relating to the electrothermic metallurgy of zinc is under way at the Mississippi Valley Experiment Station of the Bureau at Rolla, Mo. The physics and chemistry of the condensation of zinc vapor will be studied especially.

The latest census gives the number of automobiles registered in France as 236,725. On this basis, there is one automobile for every 205 persons.

The longest British railway run, and nearly the longest possible, is the new 785-mile 22-hour trip between Penzance at the southwest corner of England and Aberdeen on the northeast coast of Scotland. Through day cars are run, dining cars are attached at convenient times and sleeping cars are attached in the evening. The route is over six different lines and serves a number of important cities. This service is operated daily in each direction.

The General American Tank Car Corporation announces that the General American Car Company, one of its subsidiaries, has entered into a contract for approximately 1,100 new cars. One is with the Illinois Central Railroad for 350 refrigerator cars, and the other with the Chicago-Illinois Midland Railroad for 725 composite steel coal cars. The Atchison, Topeka & Santa Fe Railroad has ordered 1,250 refrigerator cars from the American Car & Foundry Co. and a like amount from the Haskell Barker Car Co. $8,000,000 is involved.

Humidifying and de-humidifying air in which rubber is manufactured improves the quality of rubber. It eliminates the inspection of dried rubber.

It is claimed that a greater efficiency in vulcanization is obtained and the formation of blisters is avoided. Cementing pieces of rubber together with the consequently dry surfaces, insures a better joining.

A baby airplane built to carry two hundred pounds and fitted with collapsible wings to allow it to be housed in a small garage has been set up at the General Electric Co.'s works in Pittsfield, Mass. A feature of the plane is the quick-stop device, enabling it to alight in a small space. It is claimed the plane will start with a 25-ft. run from the roof of a building.

The Chilean government has granted permission for the construction and operation of a new railway line between the port of Lebu and Los Sauces, connecting at the latter point with the state railways, and passing through Canete as reported by Charge d'Affaires John F. Martin, at Santiago.

Placing of an order for 10,000,000 pounds of copper wire by the Pacific Gas and Electric Company of San Francisco was recently announced. It is probably the largest single order for copper wire ever made. The wire will be shipped from Black Eagle, Mont., it was said, and will require 270 railroad cars for transit of the consignment.

High grade stucco will be manufactured by an Ottawa concern from magnesite obtained from the mines of Wilson, Paterson & Gifford, Ltd., Montreal, located in Quebec province. Although millions of tons of magnesite have been known for some years to be deposited in Quebec province, nothing has been done to use this material, except a limited quantity in clinkered form in the steel mills during the war.

The Du Pont Company has developed and perfected a formula for the manufacture of straight dynamite which results in that explosive being proof against freezing even in zero temperatures. Thawing, with its loss of time and attendant dangers, has practically been eliminated. The new explosive has been fully tested and proved and the formula for making it has been made standard in all the plants of the company producing dynamite.

Anyone who has stood near a 55,000-barrel tank and observed its vastness can appreciate the size of an ocean vessel capable of storing the fullness of two 55s and a part of a third, and conveying it over still or stormy seas, safe into harbor in a distant land. An oil tanker recently arrived at Bayonne, N. J., with a cargo of 126,000 barrels, or 18,000 tons of crude which had been taken on at a Mexican port.

An Italian journal is reported as estimating that if the 200,000 railway workers of that country were each employed in driving ten ton-trucks eight hours a day for 300 days a year, five times as many ton miles would be carried as by the Italian railways now.

The United States Bureau of Mines is conducting an investigation in the Nevada gold mining fields of the use of gunite in metal mines. The possibility of the cement gun being used in the preventing or minimizing of rock bursts in deep metal mines is being given attention.

The possibility of utilizing sewage gas as a driving power was indicated by J. D. Watson of Birmingham before the British Association, addressing the Engineering Section, and reported in *The Daily Chronicle*. He stated that experiments in Birmingham had shown the practicability of economically driving a suction gas engine with gas derived from sewage sludge. This was used in the plant for the purification of sewage to drive a 34 horse power gas engine. There was a complete absence of smell.

Discovery of a large deposit of fuller's earth at Northern, British Columbia, is reported by Ralph O. Jessup of New York. Mr. Jessup is now in New York, where he will endeavor to interest capital to exploit his find.

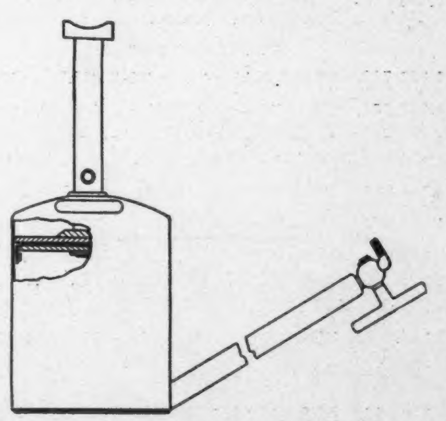
Settlement of the difference between the Chilean nitrate "pool," composed of foreign shipping and export companies on the one hand, and the association of Chilean producers on the other, in such a way as to permit the export of nitrate at prices more in line with present conditions is confidently expected in Valparaiso.

Trade Commissioner A. W. Ferrin reports that a new South Wales iron company has taken up large areas, in addition to areas already held, on the west coast of Tasmania, which contain deposits of high-grade iron ore. It is expected that at least 20,000 tons of iron ore monthly will be drawn from these deposits when the new steel plant is built at Kemble.

AN AIR OPERATED JACK

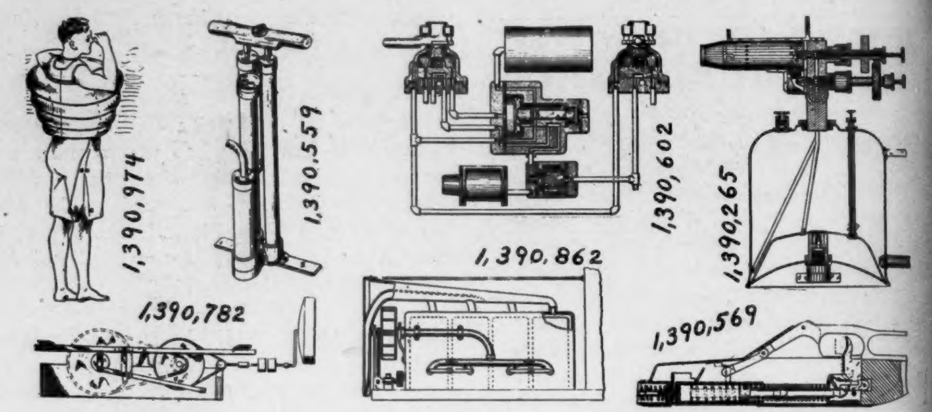
AN AUTOMOBILE jack operated by compressed air is useful in factories and garages where compressed air is available. The essential details of the jack are shown in the accompanying illustration. An 18-in. hollow handle connects to the cylinder at the bottom and extends up at an angle of about 30 deg. At the end of this handle are located an air cock and a hose connection. The piston is of the leather-cup type.

This jack, which is manufactured by the Avery Engineering Co., is made in two sizes, 6 in. and 8 in. The 6-in. jack has a piston head area of 28¼ sq. in., and, with an air pressure

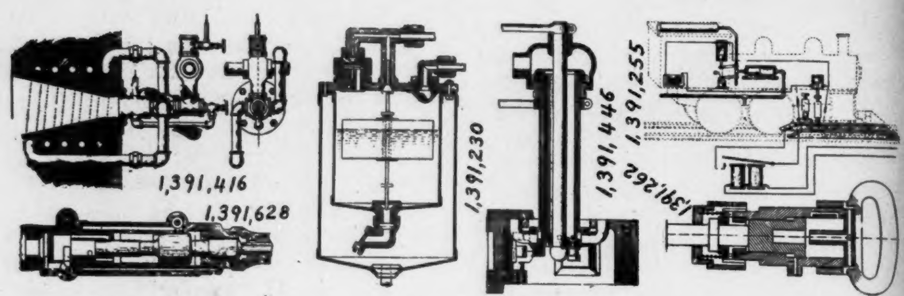


Automobile jack for use in garages where compressed air is available.

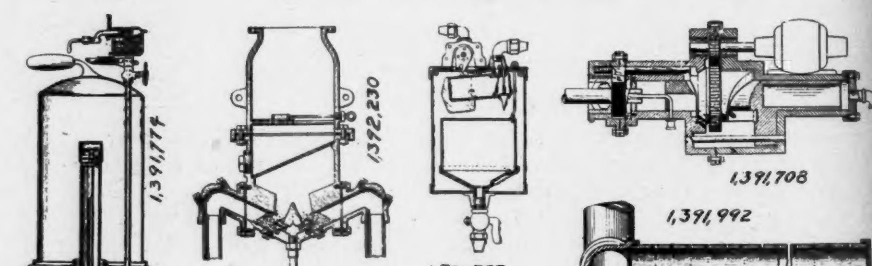
of 100 lb. per square inch, will lift 2825 lb. The 8-inch jack has a piston head area of 50¼ sq. in., and, with 100 lb. air pressure, will lift 5250 lb. By attaching a standard air gage with special dial graduations to the cylinder of the jack the latter may be used as a weighing device, indicating directly the weight on the tires. The particular advantage claimed for this type of jack is quickness of operation. It is said to take only five seconds to raise a car off the floor.



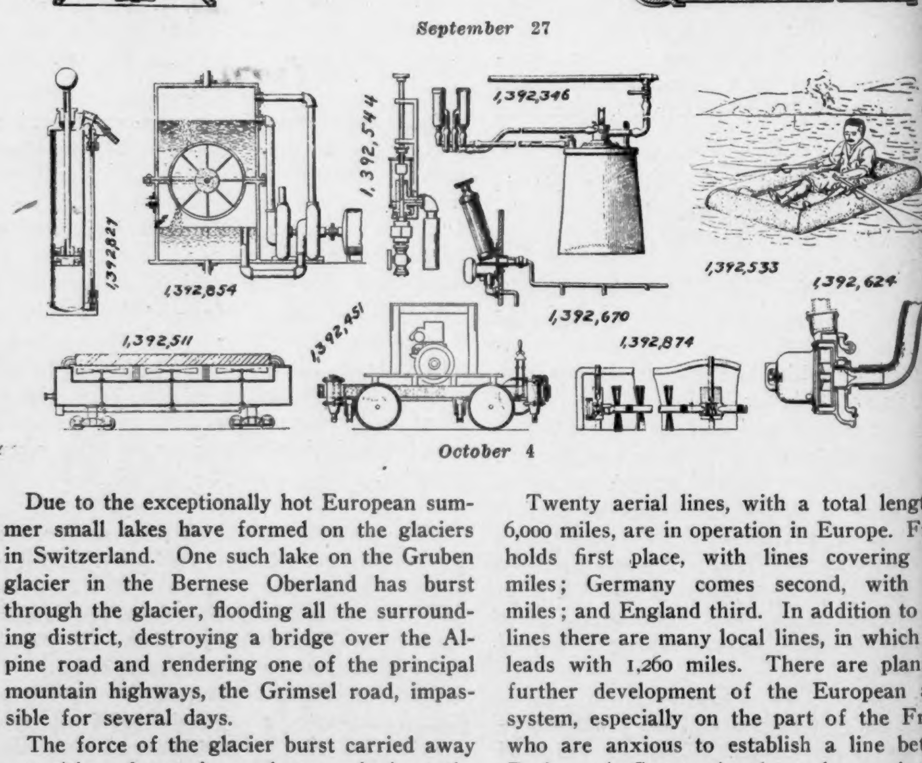
September 13



September 20



September 27



October 4

SEPTEMBER 13

1,390,264-5. BURNER - CLEANING DEVICE FOR BLOWING TORCHES. Charles H. Allen and James B. Anderson, Pittsburgh, Pa.
1,390,559. VARIABLE-POWER HAND AIR-PUMP. Charles L. Huntley, Milwaukee, Wis.
1,390,569. AIR-GUN. Charles F. Lefever, Plymouth, Mich.
1,390,602. SAFETY CAR-CONTROL DEVICE. Christopher P. Cass, St. Louis, Mo.
1,390,782. AIR - PUMP. Moses H. Hamilton, Forrest City, Ark.
1,390,862. AIR-COOLING SYSTEM. Earl H. Armes, Julesburg, Colo.
1,390,974. APPARATUS FOR STIRRING AND FEEDING OF PULVERULENT FUEL IN FURNACES FOR LOCOMOTIVES OR THE LIKE. Karl Hjalmar Vilhelm von Porat, Stockholm, Sweden.

SEPTEMBER 20

1,391,107. PLAYER-PIANO. Axel G. Gulbransen, Chicago, Ill.
1,391,104. FLUID-ACTUATED LIQUID-MEASURING PUMP. Joseph R. Gould, West Springfield, Mass.
1,391,162. PNEUMATIC HAMMER. Armand Bailly, Paris, France.
1,391,230. VACUUM FUEL-FEED DEVICE. Frederik G. Whittington, Chicago, Ill.
1,391,255. AUTOMATIC TRAIN - STOPPING MECHANISM. Newton C. Keeling, Danbury, Conn.
1,391,265. SUCTION-WASHER. Marten Manfred, Santa Barbara, Calif.
1,391,407. PNEUMATIC WHEEL. Joseph W. Ricketts, Detroit, Mich.
1,391,416. BURNER. Edward H. Schwartz, Chicago, Ill.
1,391,421. NON-SINKABLE SHIP. Stanley Sokolowski and Jakob Forgiel, Taunton, Mass.
1,391,446. FLUID-PRESSURE ENGINE. William E. Baker, Rock Island, Ill.
1,391,549. VACUUM-CAN. Stella C. Larsen, Washington, D. C.
1,391,573. MILKING APPARATUS. Leroy Nixon, Murray Hill, N. J.
1,391,628-9. PERCUSSIVE TOOL. Harry V. Haight, Sherbrooke, Quebec, Canada.

SEPTEMBER 27

1,391,708. PNEUMATIC ROCK-DRILL. Clarence R. Welch, Denver, Colo.
1,391,774. BLOWTORCH. Frederick E. Gerstenberger, South Euclid, Ohio.
1,391,793. VACUUM FEEDING DEVICE FOR CARBURETERS. Frank V. Risinger, Youngstown, Ohio.
1,391,887. PNEUMATIC HORN. Walter A. Garratt, Covington, Ky.
1,391,895. RAILWAY - BRAKE INDICATOR. Broderick Haskell, Franklin, Pa.
1,391,980. MILKING-MACHINE. Nealon D. Rutherford, Lansing, Mich.
1,391,992. PROTECTING OBJECTS FROM WAVE ACTION. Philip Brasher, New York, N. Y.
1,392,230. TRACK - SANDER. Howard M. Shade, Conemaugh, Pa.

OCTOBER 4

1,392,346. PULSATING MECHANISM. Herbert McCornack, Bloomfield, N. J.
1,392,451. AIR-LIFTING DEVICE. William N. Rowe. Hibbing, Minn.
1,392,511. AIR-COOLED LOCOMOTIVE-CONDENSER. Fredrik Ljungstrom, Brevik, Lidingon, Sweden.
1,392,533. INFLATABLE FABRIC BOAT AND BED OR CUSHION. Charles F. Smyth, New Haven, Conn.
1,392,544. ELECTROPNEUMATIC VALVE. Eugene Wiet and Foree Chittenden, San Francisco, Calif.
1,392,624. VACUUM - CLEANER. George Clements, Chicago, Ill.
1,392,670. PUMP. Raymond O. Wones, Maplewood, Ohio.
1,392,829. TIRE-PUMP. Fred Hjorth, Harlan, Iowa.
1,392,854-5-6-7. HYDRAULIC AIR-COMPRESSOR AND VACUUM-PRODUCER. Benjamin Skidmore, Jr., Chicago, Ill.
1,392,874. VACUUM-CLEANER. William C. Johnston, Milwaukee, Wis.

Due to the exceptionally hot European summer small lakes have formed on the glaciers in Switzerland. One such lake on the Gruben glacier in the Bernese Oberland has burst through the glacier, flooding all the surrounding district, destroying a bridge over the Alpine road and rendering one of the principal mountain highways, the Grimsel road, impassible for several days.

The force of the glacier burst carried away quantities of moraine and strewed about the meadows huge boulders embedded in ice for incalculable ages.

Twenty aerial lines, with a total length of 6,000 miles, are in operation in Europe. France holds first place, with lines covering 2,900 miles; Germany comes second, with 2,000 miles; and England third. In addition to these lines there are many local lines, in which Italy leads with 1,260 miles. There are plans for further development of the European aerial system, especially on the part of the French, who are anxious to establish a line between Paris and Constantinople and one between Paris and Toulouse, the latter to form part of an international line 1,800 miles long.

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